

Daily report

27-04-2020

## Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

## Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓  $\alpha$ : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓  $K$ : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to datapoints. We also discuss a specific issue every day.

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## **(0) Executive summary – Dashboard**

## Situation and trends per country

Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables. **New!** Last column ( $EPG_{EST}$ ) indicates EPG assessed with **estimated real 14-day attack rate** (see report 39 for details).  $EPG_{REP}$  is calculated with **data reported by countries**.  $EPG_{REP}$  and  $EPG_{EST}$  **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 <sup>5</sup> inh.	Cumulative deaths	Mortality /10 <sup>5</sup> inh.	Active cases (last 14 days)	14-day attack rate /10 <sup>5</sup> inh.	$\rho_3^{(1)}$	$EPG_{REP}^{(2)}$	$EPG_{EST}^{(3)}$
Spain	209,465	451.9	23,190	50.0	40,390	87.1	0.91	80	911
Italy	197,675	332.6	26,644	44.8	41,312	69.5	0.92	64	908
Germany	155,193	189.5	5,750	7.0	32,177	39.3	0.90	35	157
United Kingdom	152,840	230.0	20,732	31.2	68,561	103.2	0.92	95	1,460
France	124,575	192.5	22,856	35.3	29,172	45.1	1.00	45	901
Belgium	46,134	406.2	7,094	62.5	16,487	145.2	0.89	130	2,542
Netherlands	37,845	222.8	4,475	26.3	12,258	72.2	0.77	56	716
Switzerland	28,978	338.1	1,336	15.6	3,758	43.9	0.74	32	162
Portugal	23,864	230.1	903	8.7	7,279	70.2	0.90	63	274
Ireland	19,262	407.6	1,087	23.0	9,607	203.3	1.17	237	1,754
Sweden	18,640	189.5	2,194	22.3	8,157	82.9	1.29	107	1,984
Austria	15,189	174.3	542	6.2	1,252	14.4	1.09	16	58
Poland	11,617	30.4	535	1.4	4,943	12.9	0.89	11	71
Romania	11,036	55.8	608	3.1	4,736	23.9	1.11	27	172
Denmark	8,575	150.1	422	7.4	2,401	42.0	1.11	47	253
Norway	7,505	139.8	193	3.6	1,090	20.3	0.81	16	46
Czech Republic	7,404	69.8	221	2.1	1,413	13.3	0.60	8	28
Finland	4,576	83.2	190	3.5	1,602	29.1	0.90	26	141
Luxembourg	3,723	646.4	88	15.3	442	76.7	0.72	56	ND
Hungary	2,583	26.5	280	2.9	1,125	11.5	0.95	11	170
Greece	2,506	22.4	130	1.2	392	3.5	1.99	7	43
Croatia	2,030	48.2	55	1.3	430	10.2	0.96	10	ND
Iceland	1,792	492.0	10	2.7	91	25.0	0.26	6	ND
Estonia	1,643	125.2	49	3.7	334	25.5	0.95	24	ND
Lithuania	1,449	49.8	41	1.4	387	13.3	0.38	5	ND
Slovenia	1,407	67.7	82	3.9	202	9.7	1.15	11	ND
Slovakia	1,379	25.3	18	0.3	637	11.7	0.80	9	ND
Bulgaria	1,300	18.2	56	0.8	625	8.8	2.21	19	ND
Cyprus	817	69.8	17	1.5	184	15.7	0.71	11	ND
Latvia	812	41.2	12	0.6	161	8.2	0.80	7	ND
Malta	448	104.4	4	0.9	70	16.3	ND	ND	ND
Liechtenstein	83	215.3	1	2.6	3	7.8	ND	ND	ND

Scale								
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500
Best	Best	Best	Best	Best	Best	Best	0.0	0

- (1) Disclaimer: parameter  $\rho$  is very sensitive and experiments daily variations.  $\rho_3$  is the average of 3 consecutive  $\rho$ , but can still fluctuate. (2) EPG stands for Effective Growth Potential.  $EPG_{REP}$  is obtained by multiplying attack rate of last 14 days per 10<sup>5</sup> inhabitants (i.e. density of cases) by  $\rho_3$  (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days).  $EPG_{EST}$  is obtained by multiplying estimated real attack rate of last 14 days per 10<sup>5</sup> inhabitants by  $\rho_3$ .

## Highlights for countries with highest number of reported cases

- ✓ Spain is now reporting only PCR+ cases, after a few days of including antibody's tests. Then, expected daily new cases are decreased until the level of 2,000-1,500. Italy and Germany follow the expected decrease, with a forecast of 2,400-2,100 and 1,700-1,200, respectively. France could be below the level of 1,000 cases in one or to days.
- ✓ New  $\rho_7$  is around 1 for UK, 0.9 for Spain, France and Italy, and 0.8 for Germany.

## Time indicators by country

This table summarizes a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of  $1/10^5$  inhabitants and an attack rate of  $10/10^5$  inhabitants, and time interval between attack rates of 10 to 100 per  $10^5$  inhabitants (only for countries that have overtaken this threshold).

Countries	Days since the first 50 cases	Time interval between 1 and 10 cases / $10^5$ inh. (days)	Time interval between 10 and 100 cases / $10^5$ inh. (days)
Italy	65	11	16
France	59	10	20
Germany	59	12	17
Spain	58	7	12
United Kingdom	55	11	19
Norway	54	9	24
Switzerland	54	9	12
Netherlands	53	11	20
Sweden	53	10	28
Austria	52	10	14
Belgium	52	11	14
Greece	51	18	ND
Iceland	51	5	15
Denmark	49	4	30
Czech Republic	48	11	ND
Finland	47	12	ND
Portugal	47	9	15
Slovenia	47	6	ND
Ireland	46	8	18
Romania	46	15	ND
Estonia	45	5	30
Poland	45	14	ND
Bulgaria	43	17	ND
Luxembourg	43	6	7
Slovakia	43	19	ND
Croatia	42	12	ND
Latvia	41	12	ND
Cyprus	40	12	ND
Hungary	40	14	ND
Malta	39	8	34
Lithuania	38	9	ND
Liechtenstein	33	9	11

## Analysis: Weekend effect and data analysis in an epidemic.

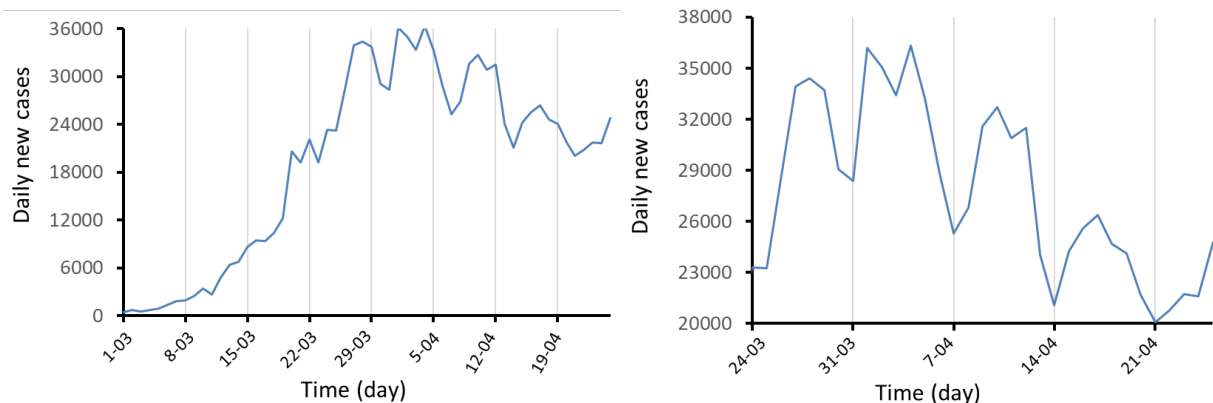
Real-time data analysis during an epidemic is essential to assess its magnitude and effects and to plan control actions with a good understanding of the situation. Besides, the effects of implemented control actions have to be measured so that these actions can be modified, if necessary. **There is a wide consensus on the interest of measuring the spreading or growth rate of infectious disease as a good way to observe its dynamics and trend.** SIR and SEIR models allow determining the effective reproduction number,  $R_t$ , which is a measurement of this rate. Nevertheless, the fitting of these kind models to a new disease is not straightforward, because most of the involved parameters are still not well known. Therefore, many assumptions are to be made. Moreover, when the dynamics of infection is strongly determined by control actions, these models are not the most appropriate.

This assessment pushed us to find an empirical way of measuring the spreading rate. We finally opted for  $\rho$ , which we defined as:

$$\rho(t) = \frac{N(t-1) + N(t) + N(t+1)}{N(t-6) + N(t-5) + N(t-4)}$$

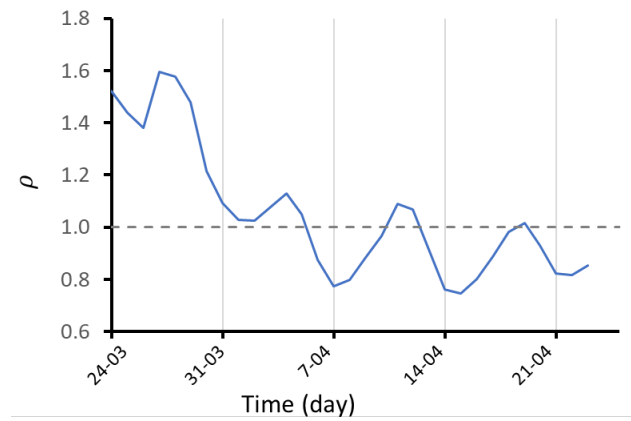
During the first weeks, the methodology employed showed its appropriateness. Nevertheless, once the peak in new cases has been overcome, we have detected an artefact that we would like to correct so that erroneous conclusions are not derived from the observation of  $\rho$ : weekend effect.

The next figure shows the **number of daily new cases** for EU+EFTA+UK countries from 1st March. Vertical grey bars indicate weeks. During the growth phase, the weekend effect is not observed. Nevertheless, the decrease is a concatenation of small peaks that coincide with weeks. If we zoom the last part of the plot, oscillations with a period of 7 days are clearly seen (right).

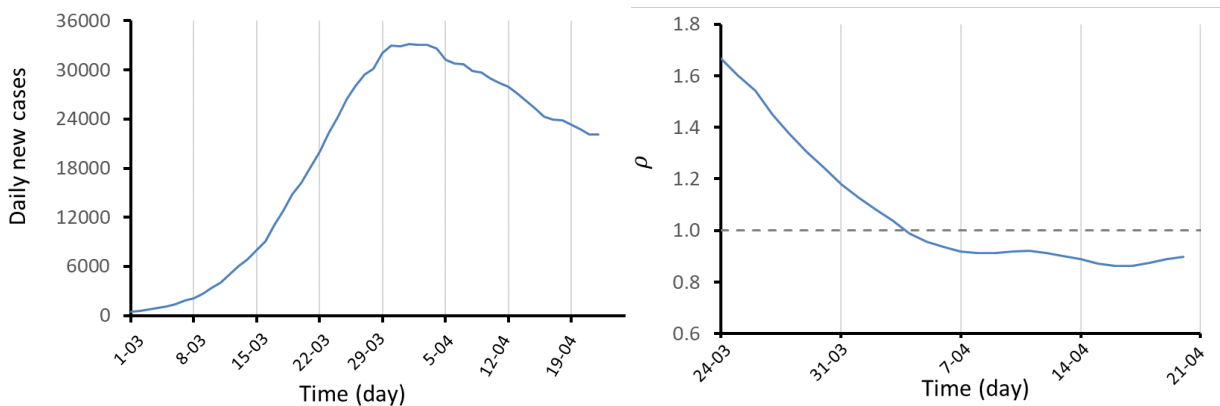


These plots have been built with ECDC data. **Minimum values are always found on Tuesdays, which corresponds to data reported by each country's health system on Sunday** (i.e., Sundays' data are published by countries' governments on Monday, then sent to EU official bodies and published by the ECDC on Tuesdays). Therefore, these periodic minimums seem to be a **strong effect of weekends**, either because of an associate delay in data reporting or because of a reduction in personnel and attention capacity in the hospitals. In any case, these oscillations would not be related to the epidemic itself but with management issues

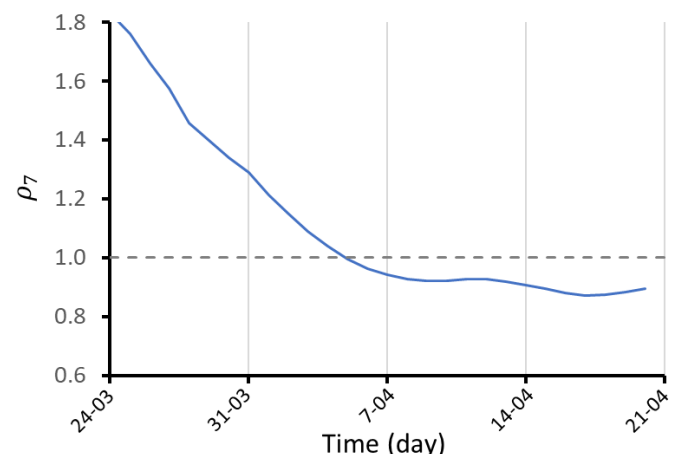
If we look at the corresponding  $\rho$  dynamics during the decreasing period, we see a set of oscillations that are in accord with those observed in new cases.



Therefore, **oscillations in  $p$  do not have an epidemiological meaning** but are the consequence of a *weekend effect*. An alternative way of observing the epidemiological dynamics in new cases is the use of a **7-day moving average**. The left figure shows the daily new case using this 7-day moving average. As seen, oscillations have disappeared and we are able to discern the real dynamics of the epidemic. The figure in the right shows the corresponding  $p$ , which provides a better picture of the sustained decrease in the spreading rate.

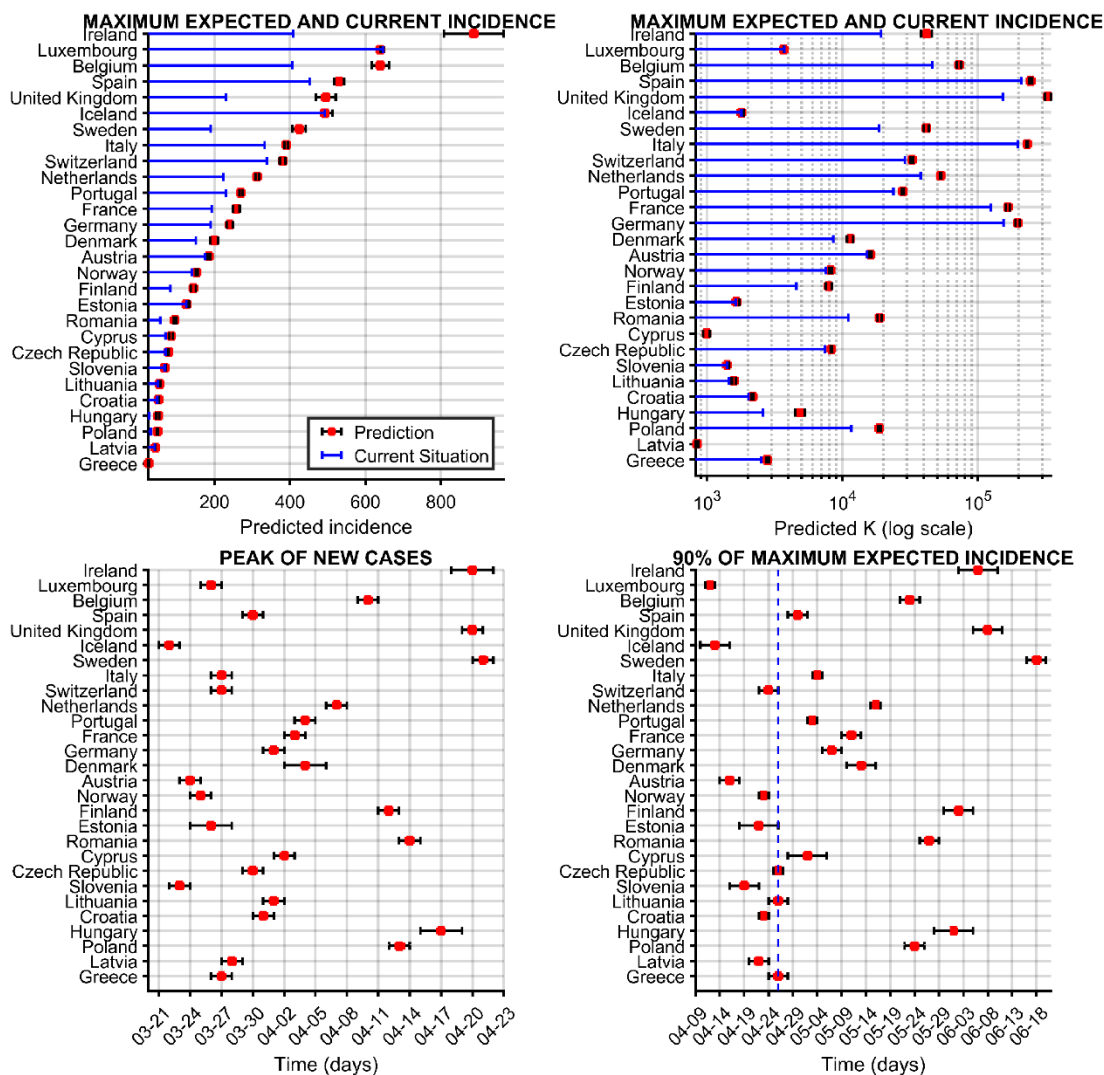


Another way of assessing an equivalent spreading rate is to evaluate  $p$  with original data and then applying the 7-day moving average to  $p$  values. This is what we name  $p_7$ , and its plot is shown below. Resulting values are slightly different from those calculated from averaged new cases, but obtained dynamics is equivalent. Therefore, we conclude that both procedures are adequate. Both approaches for eliminating weekend effect and assessing the real dynamics of the epidemic show that **spreading rate in EU+EFTA+UK has been below 1 for the last 2 weeks in a sustained manner**.

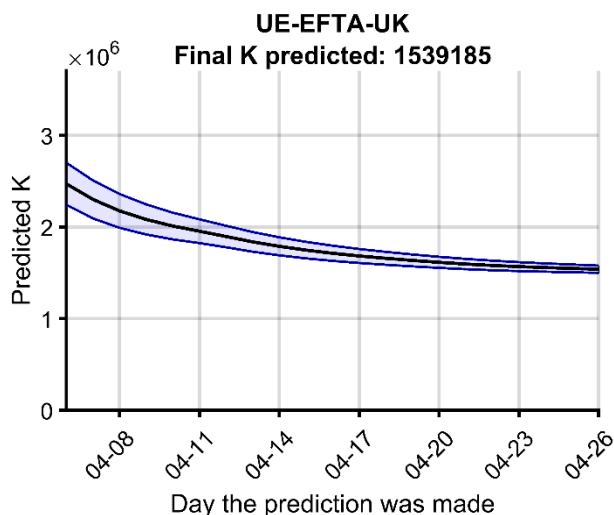


## Long-term predictions

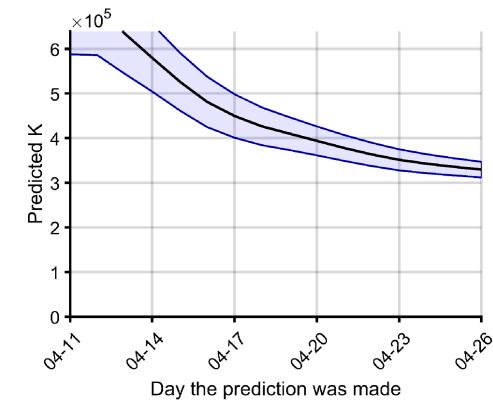
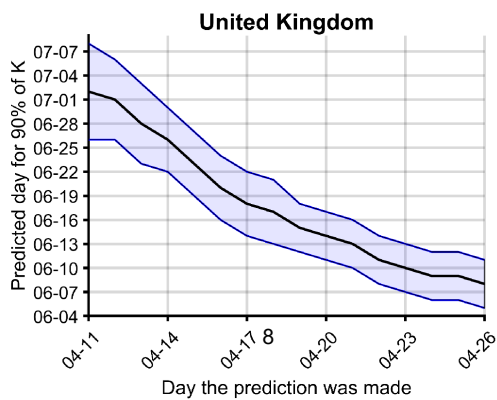
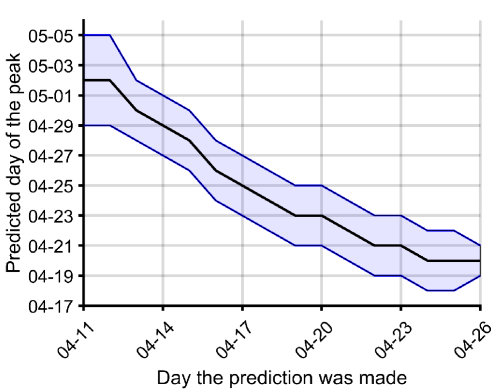
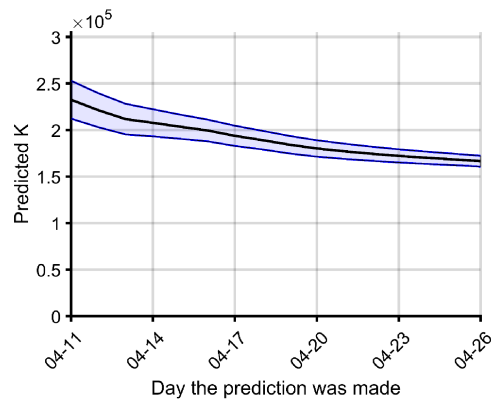
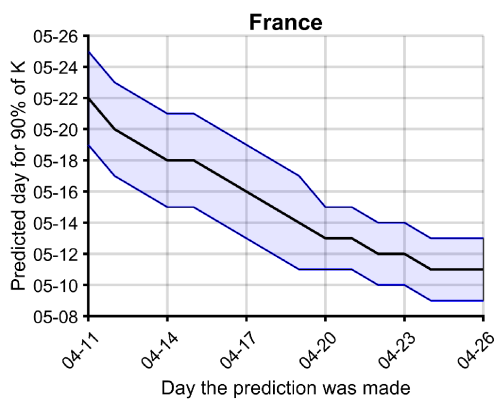
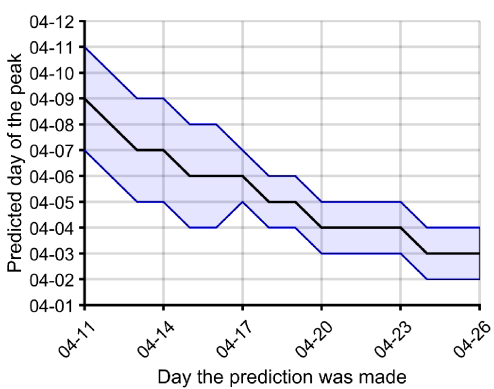
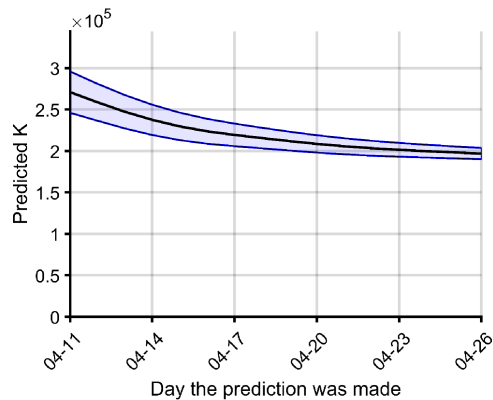
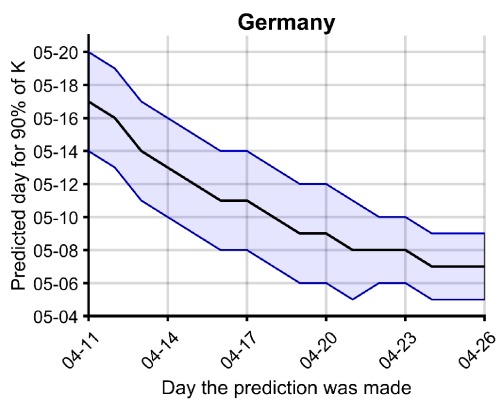
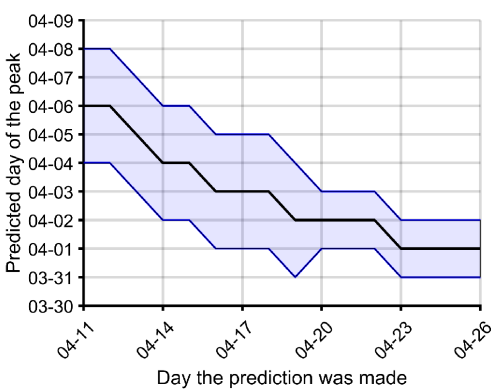
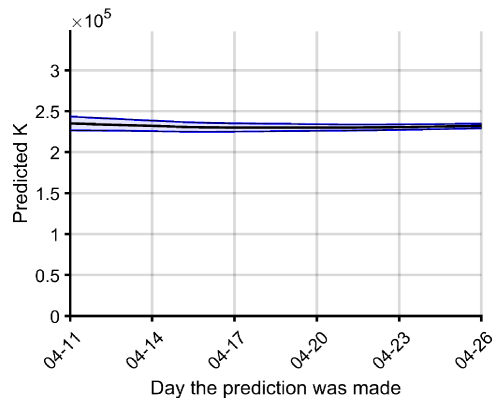
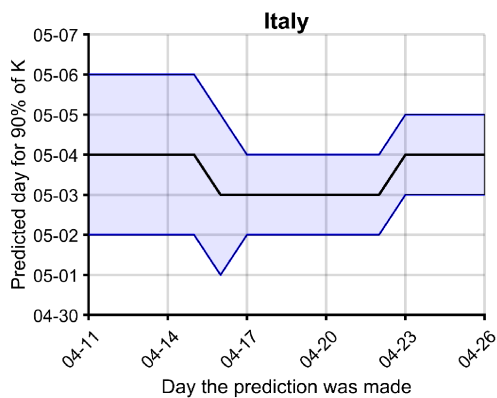
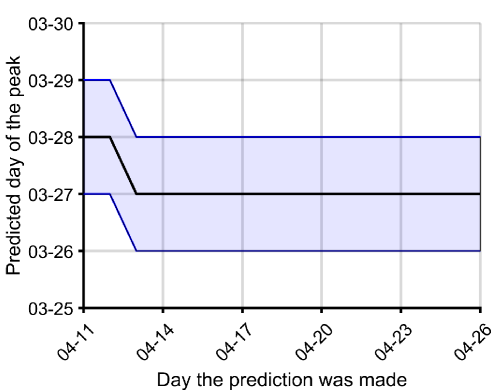
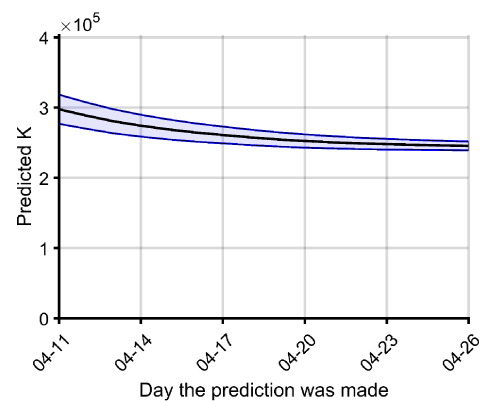
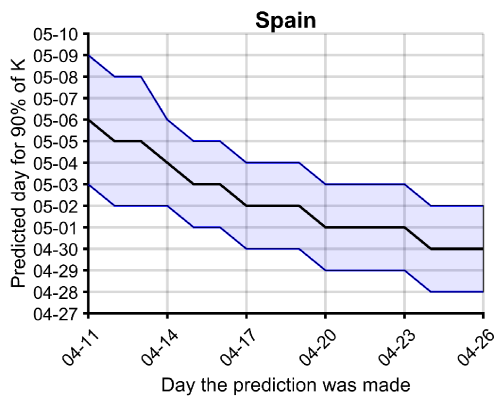
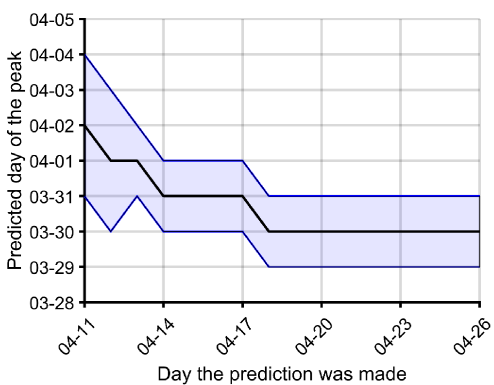
**Long-term predictions**, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per  $10^5$  inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.



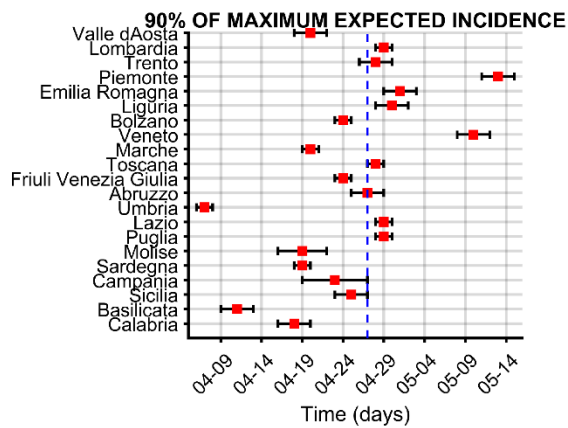
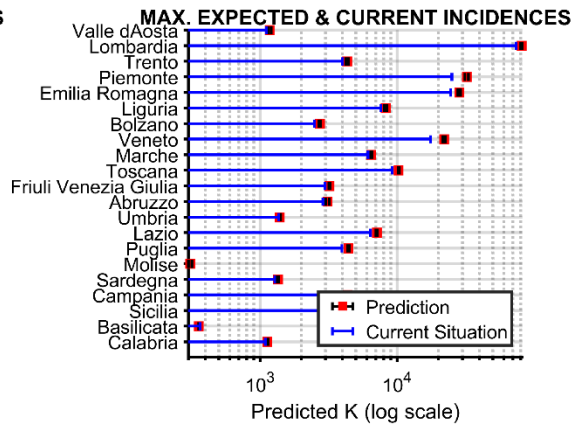
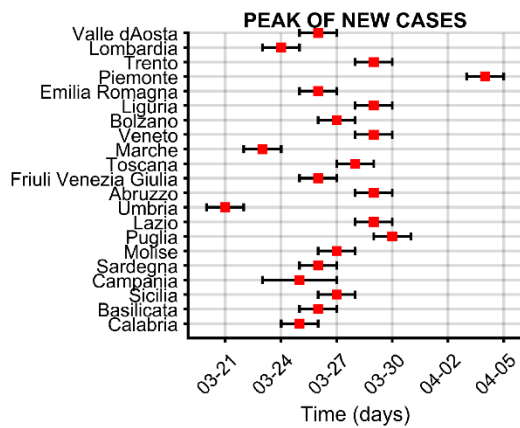
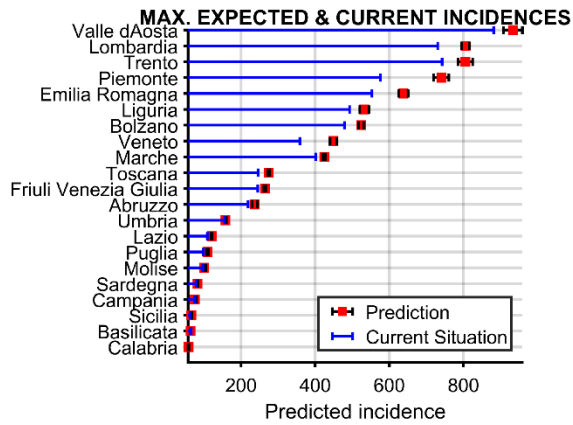
**Final expected K for UE+EFTA+UK.** Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown in title.



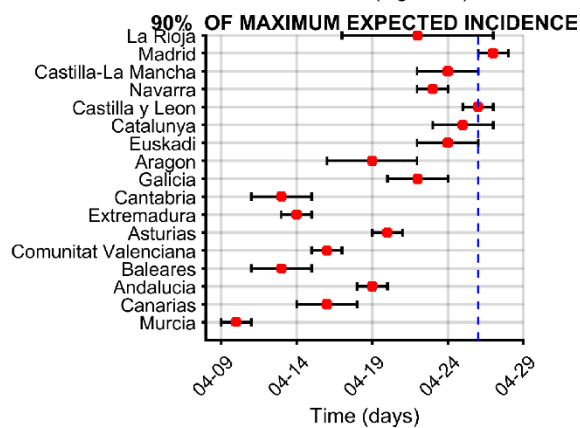
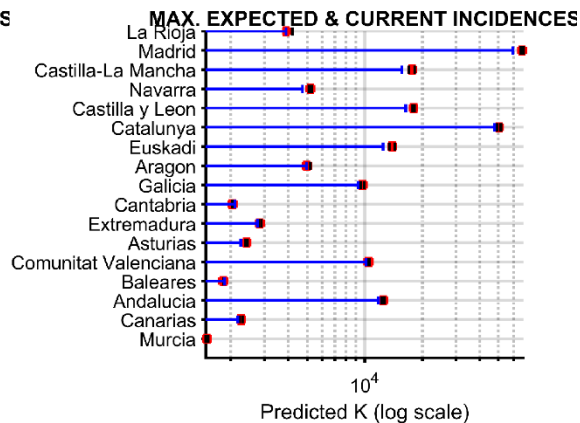
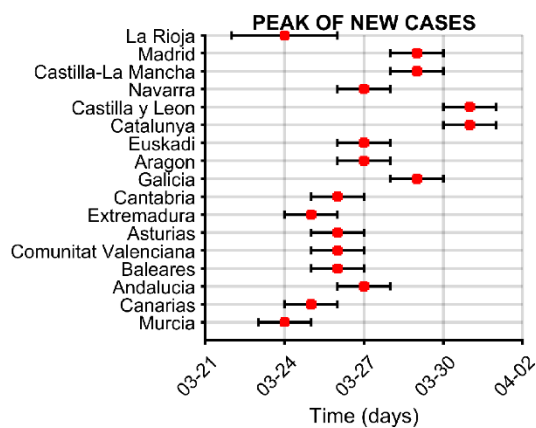
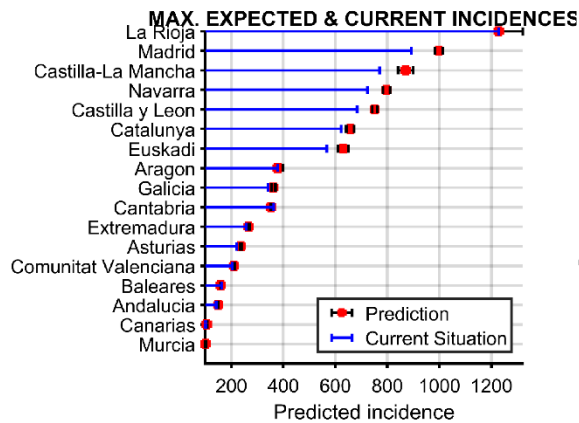
**2020-04-26**



## Italian regions

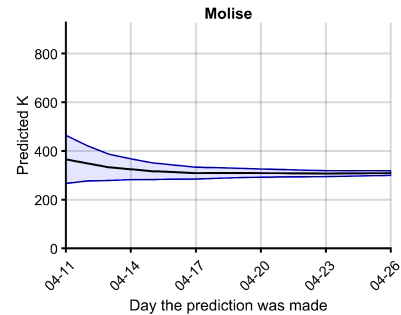
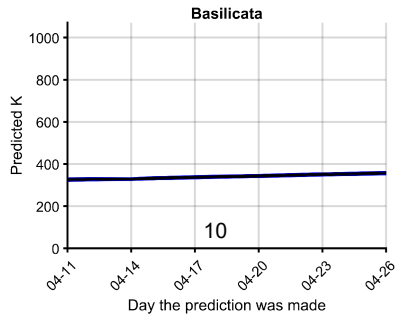
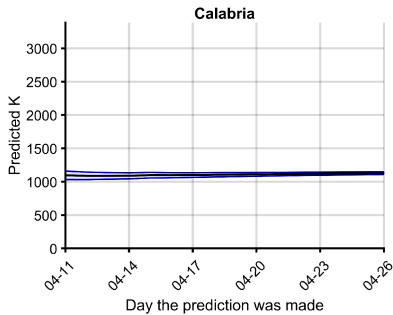
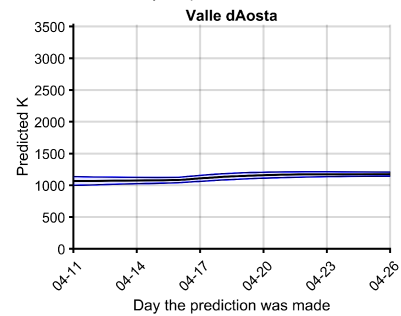
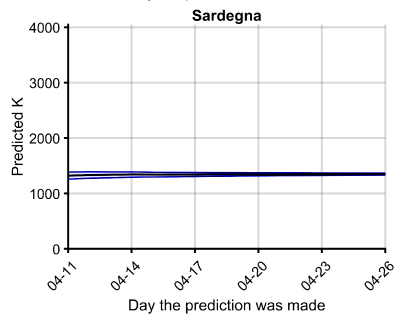
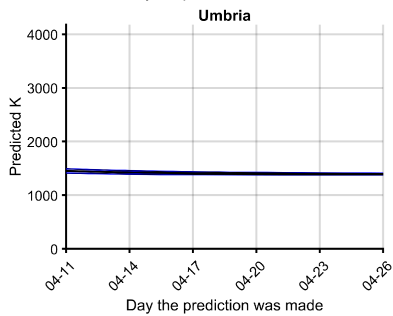
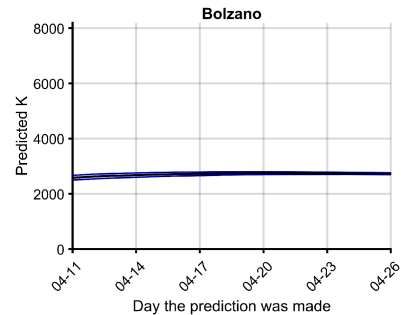
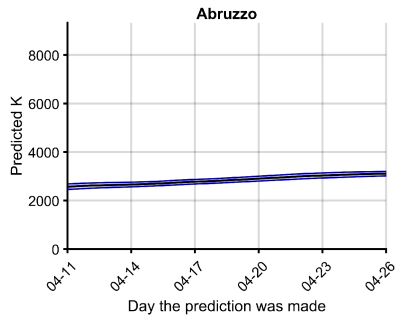
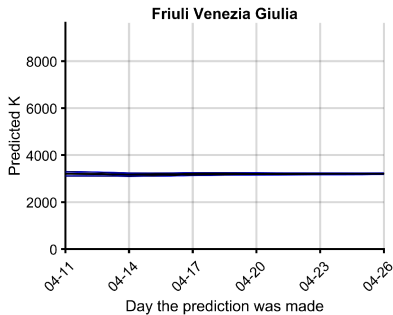
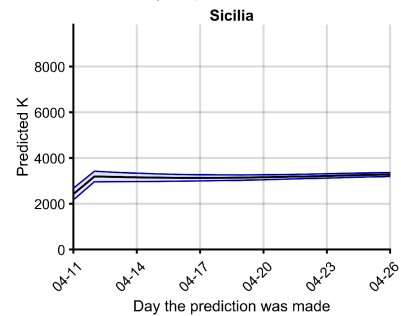
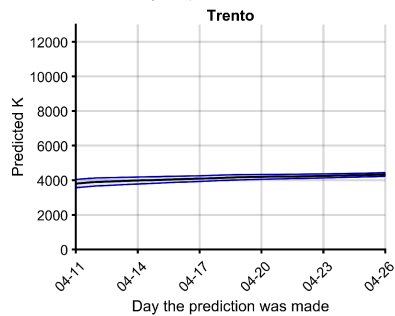
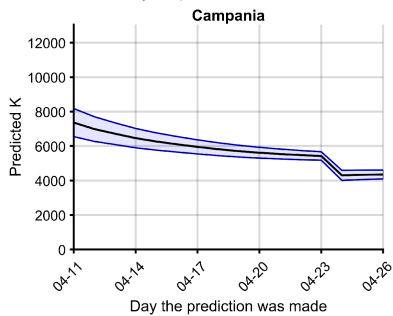
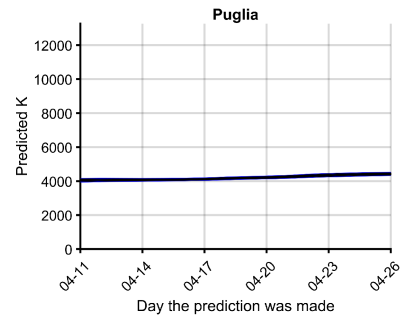
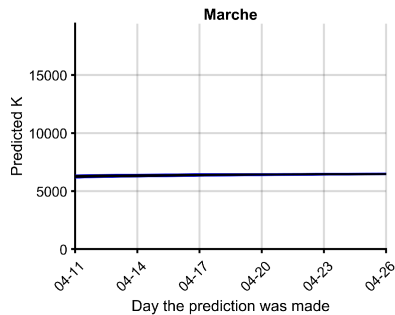
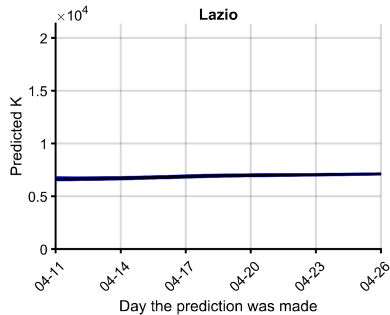
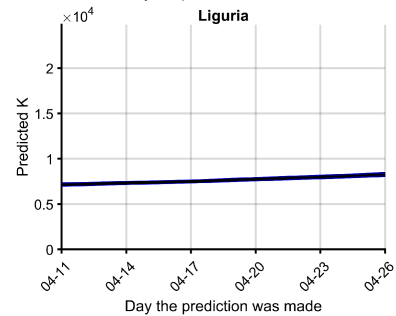
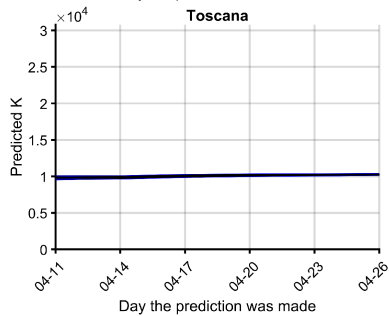
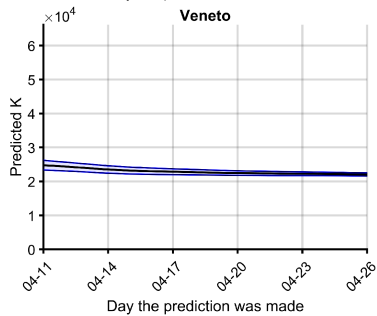
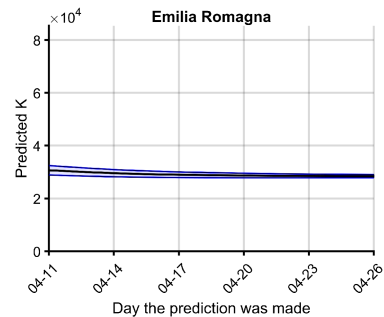
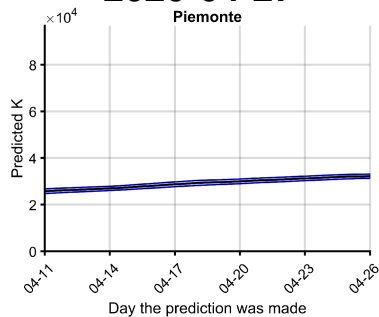
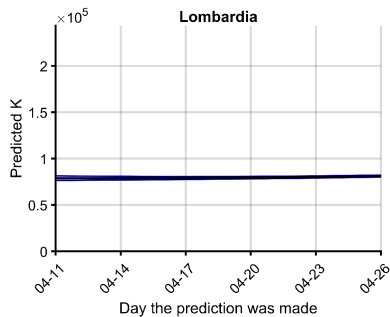


## Spanish regions

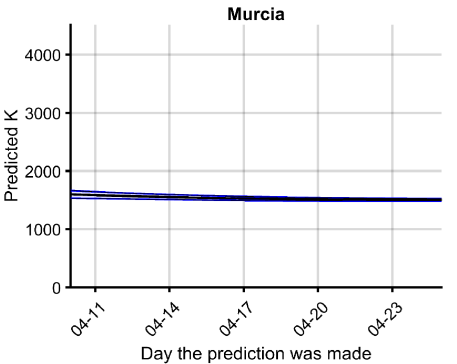
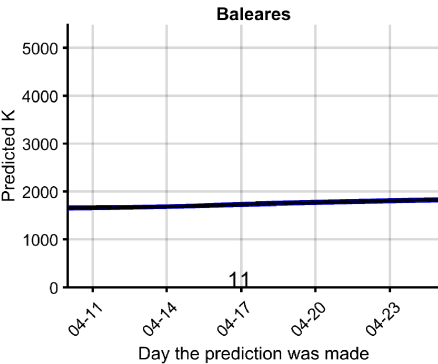
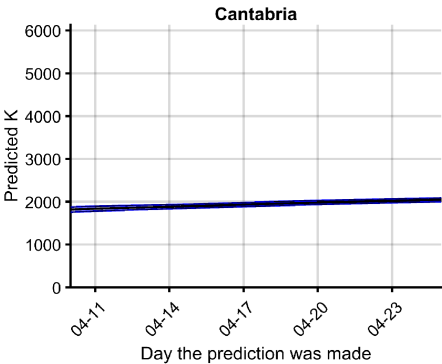
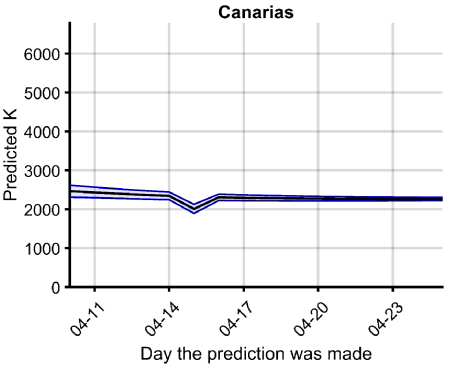
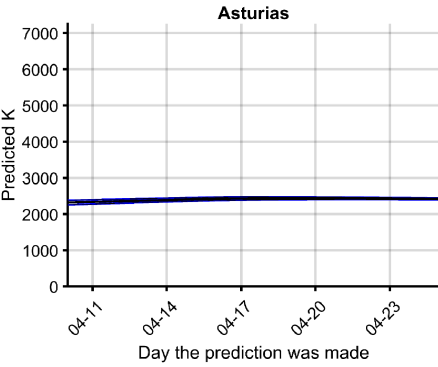
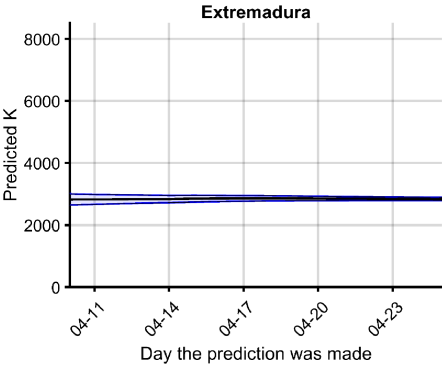
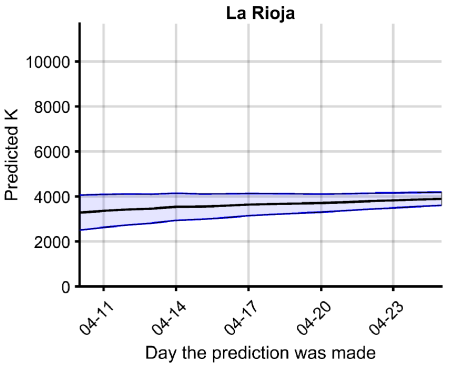
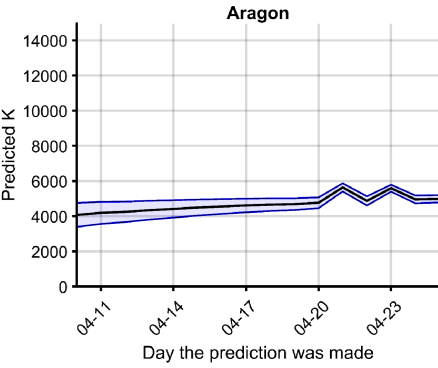
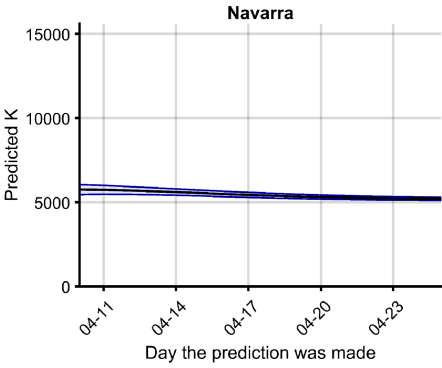
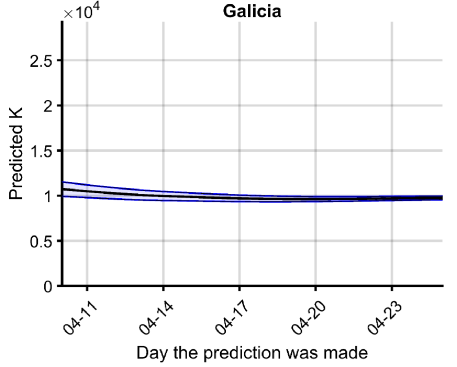
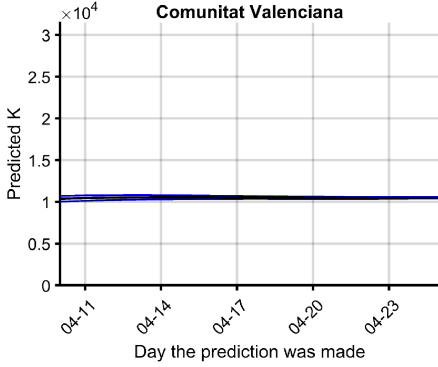
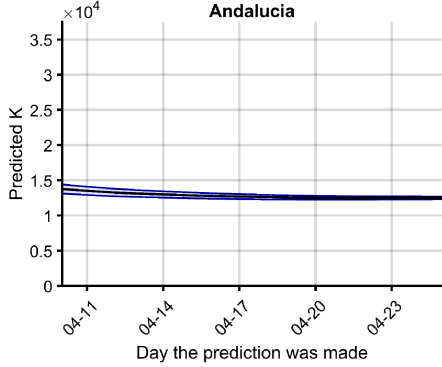
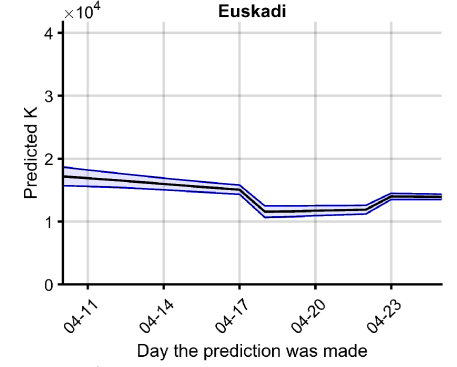
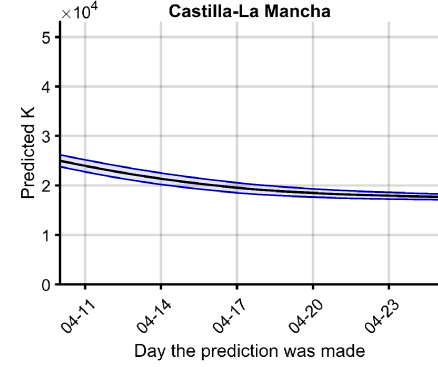
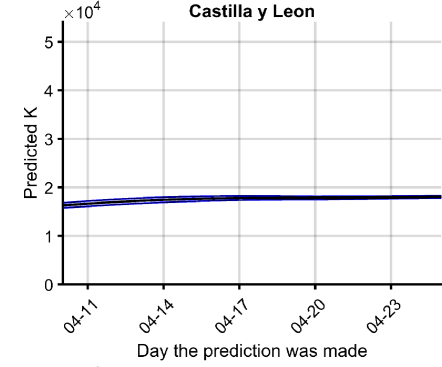
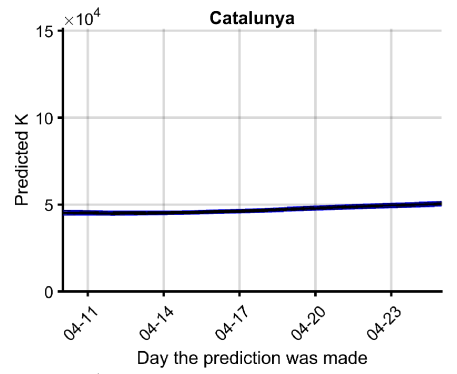
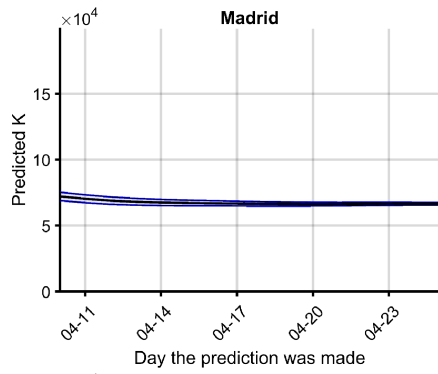
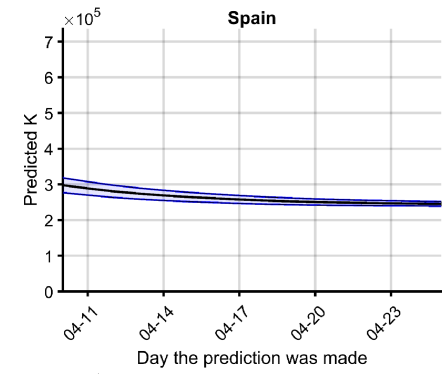




2020-04-27



2020-04-26



## Situation and trends in Italian and Spanish regions

### Italy

Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 <sup>5</sup> inh.	Cumulative deaths	Mortality / 10 <sup>5</sup> inh.	Active cases (last 14 days)	14-day attack rate / 10 <sup>5</sup> inh.	$\rho_3^{(1)}$	EPG <sub>REP</sub> <sup>(2)</sup>	EPG <sub>EST</sub> <sup>(3)</sup>
Lombardia	73,479	731.7	13,449	133.9	13,165	131.1	0.95	125	2,416
Piemonte	25,098	576.1	2,878	66.1	7,964	182.8	0.99	181	2,302
Emilia Romagna	24,662	553.0	3,431	76.9	4,222	94.7	0.78	74	1,077
Veneto	17,579	358.3	1,344	27.4	3,328	67.8	0.71	48	408
Toscana	9,179	246.1	795	21.3	1,789	48.0	0.91	43	417
Liguria	7,642	492.8	1,128	72.7	2,046	131.9	0.98	130	2,044
Lazio	6,392	108.7	397	6.8	1,424	24.2	1.05	26	167
Marche	6,127	401.7	884	58.0	746	48.9	0.84	41	624
Campania	4,349	75.0	352	6.1	679	11.7	0.66	8	64
Trento	3,995	372.6	407	38.0	869	81.0	1.24	101	2,238
Puglia	3,958	98.2	405	10.1	893	22.2	0.55	12	140
Sicilia	3,085	61.7	231	4.6	627	12.5	0.81	10	84
Friuli Venezia Giulia	2,977	245.0	271	22.3	495	40.7	1.05	43	414
Abruzzo	2,874	219.1	299	22.8	661	50.4	0.44	22	244
Bolzano	2,496	2,323.2	270	251.3	347	323.0	0.75	244	586
Umbria	1,370	155.3	65	7.4	50	5.7	0.73	4	ND
Sardegna	1,283	78.3	109	6.6	155	9.5	0.66	6	56
Valle d'Aosta	1,111	884.5	133	105.9	184	146.5	0.71	104	1,235
Calabria	1,096	56.3	83	4.3	168	8.6	0.61	5	ND
Basilicata	366	65.0	25	4.4	47	8.4	0.94	8	ND
Molise	296	96.9	21	6.9	39	12.8	1.13	14	ND

Scale								
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500
Best	Best	Best	Best	Best	Best	Best	0.0	0

### Spain

Autonomous regions	Reported data						Indexes		
	Cumulative cases	Attack rate /10 <sup>5</sup> inh.	Cumulated deaths	Mortality rate /10 <sup>5</sup> inh.	Active cases (last 14 days)	14-day attack rate /10 <sup>5</sup> inh.	$\rho_3^{(1)}$	EPG <sub>REP</sub> <sup>(2)</sup>	EPG <sub>EST</sub> <sup>(3)</sup>
Madrid	59,421	894.8	7,986	120.3	12,275	184.8	0.82	151	2,073
Catalunya	47,755	631.3	4,699	62.1	13,029	172.2	0.67	115	1,215
Castilla y Leon	16,404	681.2	1,690	70.2	3,776	156.8	1.29	202	2,235
Castilla-La Mancha	15,664	769.5	2,365	116.2	1,710	84.0	1.44	121	1,914
Euskadi	12,513	574.5	1,241	57.0	1,495	68.6	7.39	507	5,459
Andalucia	11,852	140.7	1,157	13.7	1,757	20.9	1.06	22	234
Comunitat Valenciana	10,180	204.6	1,189	23.9	1,120	22.5	1.42	32	399
Galicia	9,238	342.1	405	15.0	1,744	64.6	1.11	72	347
Aragon	4,985	377.4	726	55.0	798	60.4	0.89	54	856
Navarra	4,733	728.2	432	66.5	641	98.6	1.1	104	1,049
La Rioja	3,892	1,241.1	320	102.0	534	170.3	1.23	209	1,833
Extremadura	2,749	258.0	428	40.2	265	24.9	1.03	26	408
Asturias	2,254	220.5	253	24.7	296	29.0	0.43	13	160
Canarias	2,178	98.7	131	5.9	234	10.6	0.98	10	67
Cantabria	2,104	361.7	186	32.0	327	56.2	0.72	41	391
Baleares	1,859	156.5	179	15.1	309	26.0	0.9	23	243
Murcia	1,474	99.1	128	8.6	66	4.4	0.68	3	27
Melilla	110	129.8	2	2.4	9	10.6	ND	ND	ND
Ceuta	100	117.9	4	4.7	5	5.9	ND	ND	ND

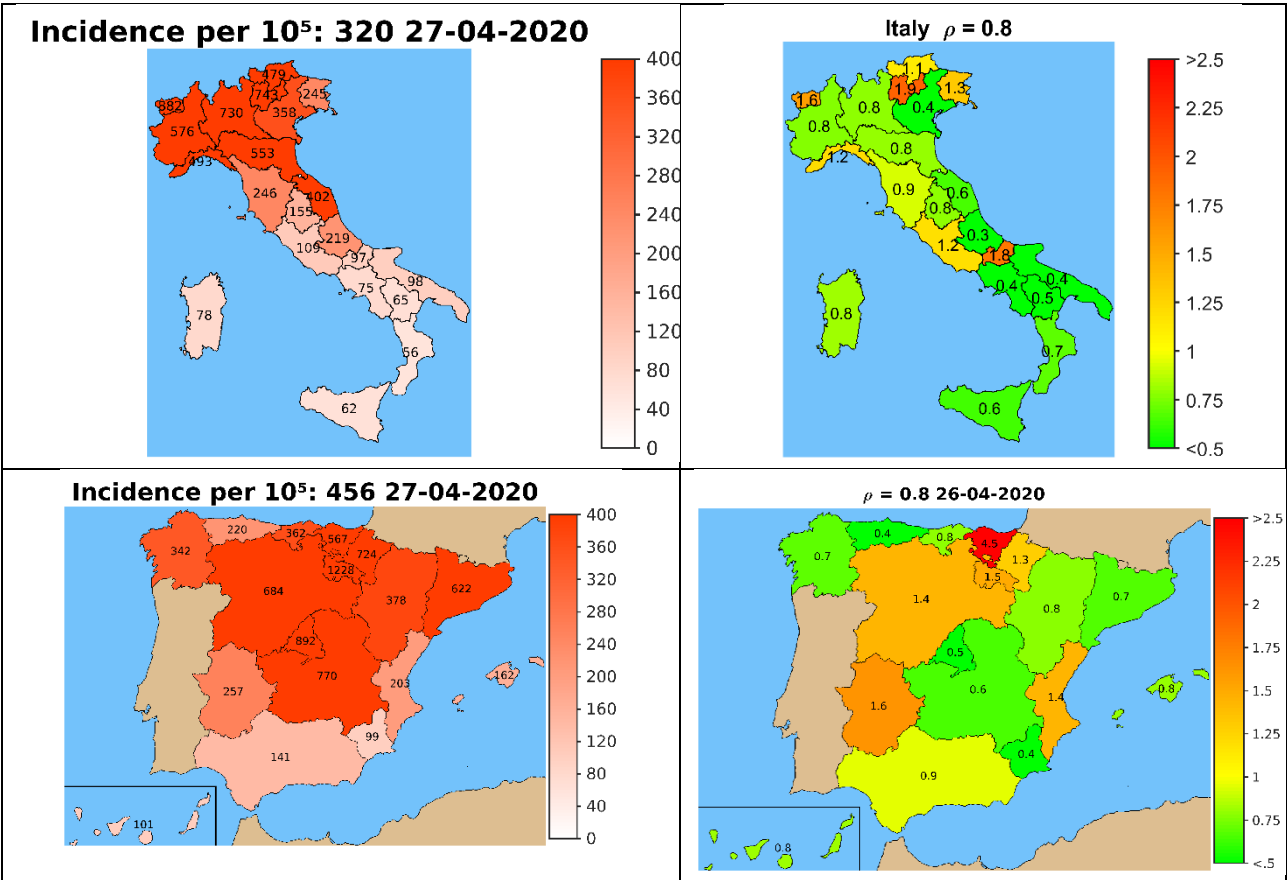
  

Scale								
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500
Best	Best	Best	Best	Best	Best	Best	0.0	0

<sup>(1)</sup> Disclaimer: parameter  $\rho$  is very sensitive and experiments daily variations.  $\rho_3$  is the average of 3 consecutive  $\rho$ , but can still fluctuate. <sup>(2)</sup> EPG stands for Effective Growth Potential. EPG<sub>REP</sub> is obtained by multiplying attack rate of last 14 days per 10<sup>5</sup> inhabitants (i.e. density of cases) by  $\rho_3$  (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG<sub>EST</sub> is obtained by multiplying estimated real attack rate of last 14 days per 10<sup>5</sup> inhabitants by  $\rho_3$ .

# Maps of Italian and Spanish regions

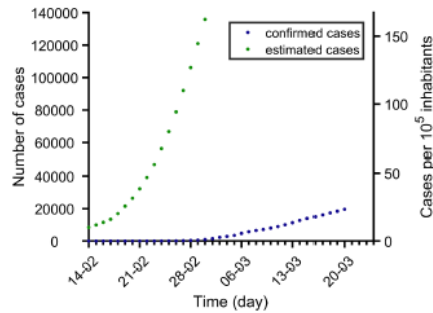
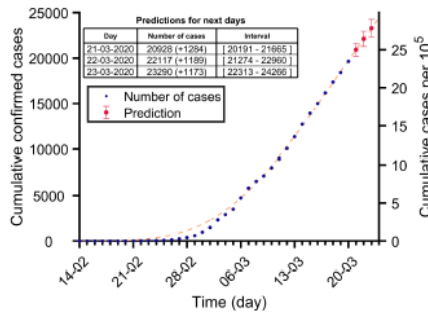
Cumulative incidence and spreading rate ( $\rho$ ) in Italian regions.



## Legend: Countries' reports details

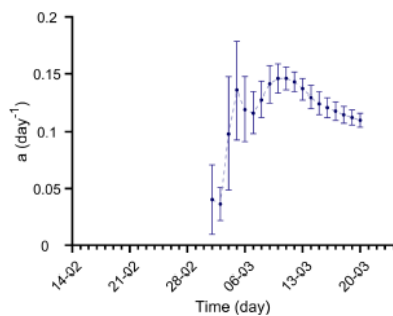
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence:  $23/10^5$

Confirmed cases:  
data (blue),  
model fitted  
(dashed line),  
predictions (red  
points and table)

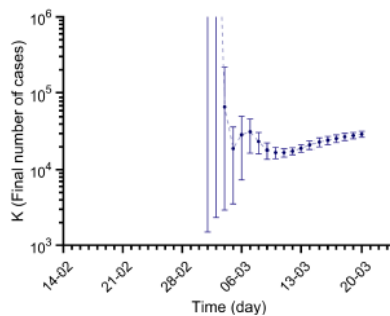


Estimated  
cases using  
death rate (see  
Methods)

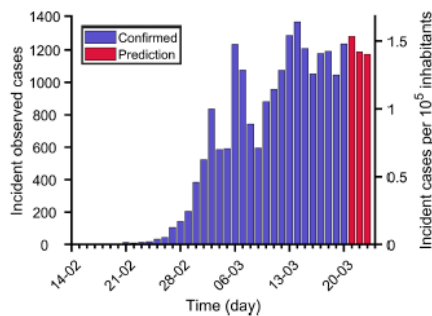
Fitted  $a$  value  
using points  
prior to each  
date



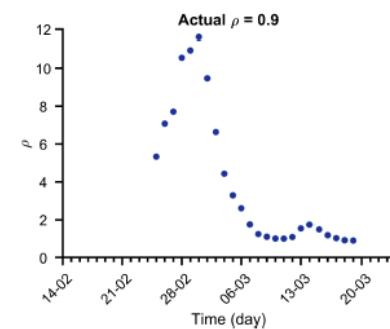
Fitted  $K$  value  
using points  
prior to each  
date



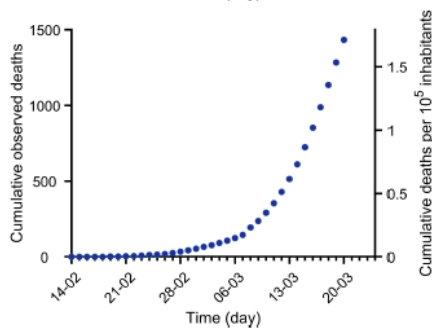
Reported  
and  
predicted  
new cases



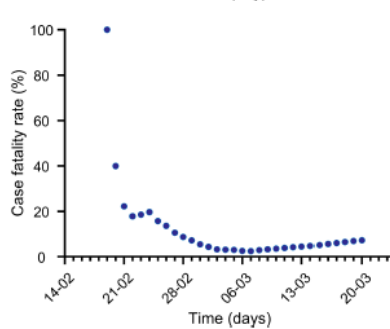
Evolution of  $\rho$ , a  
parameter related  
with Reproduction  
number (see  
Methods)



Reported  
deaths

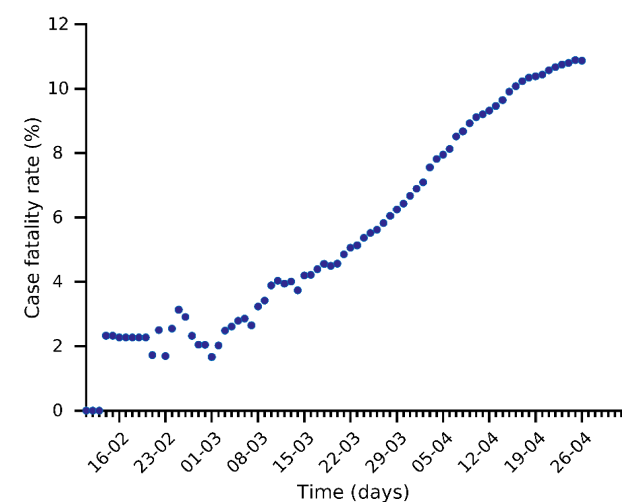
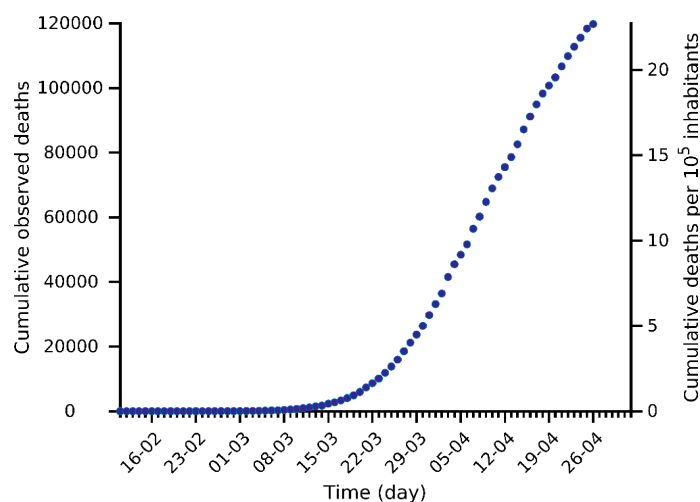
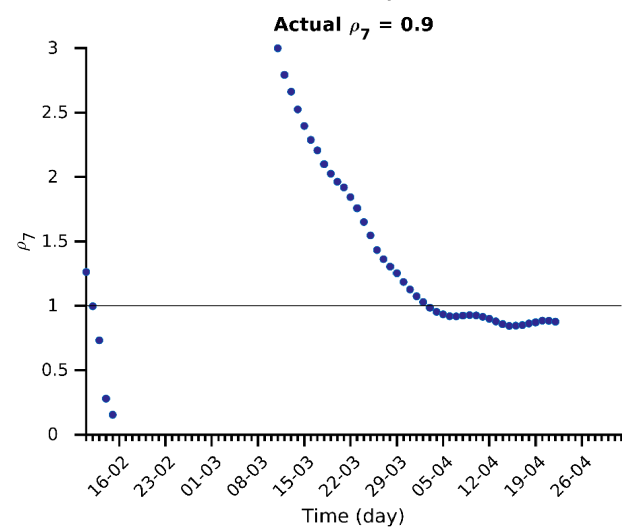
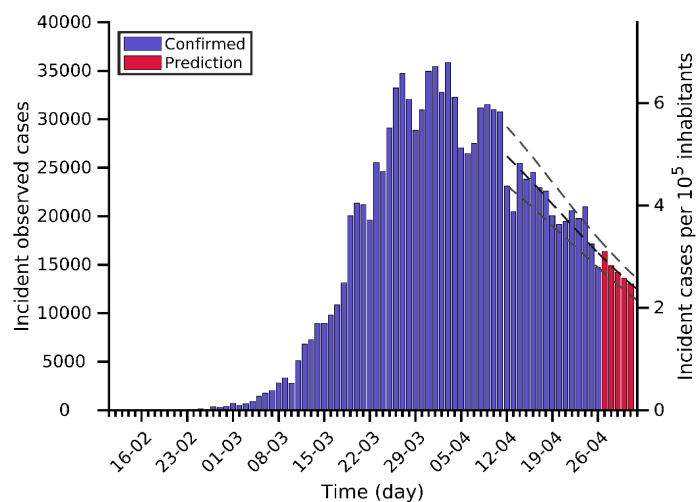
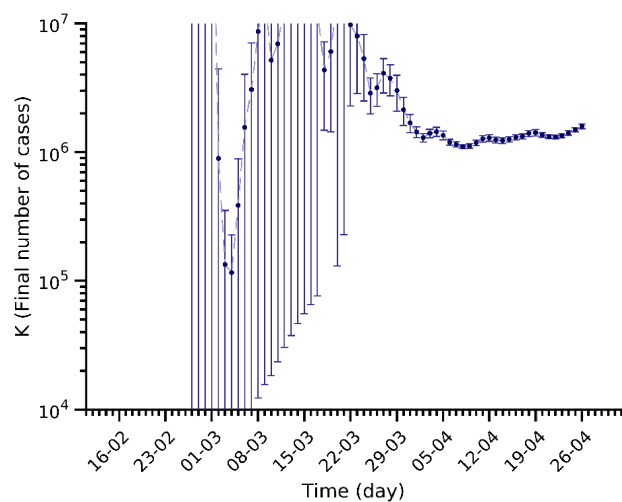
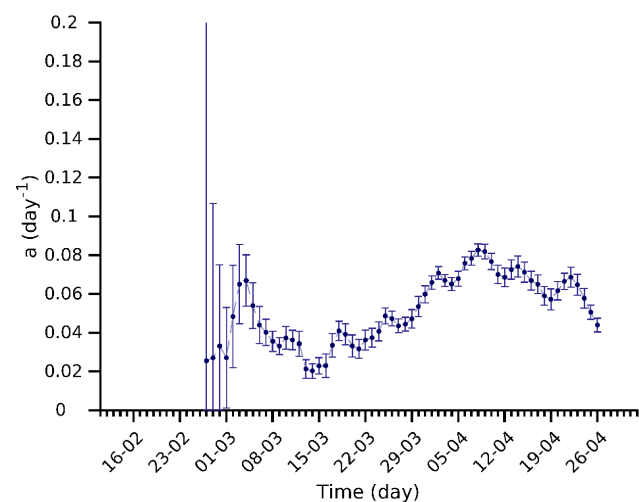
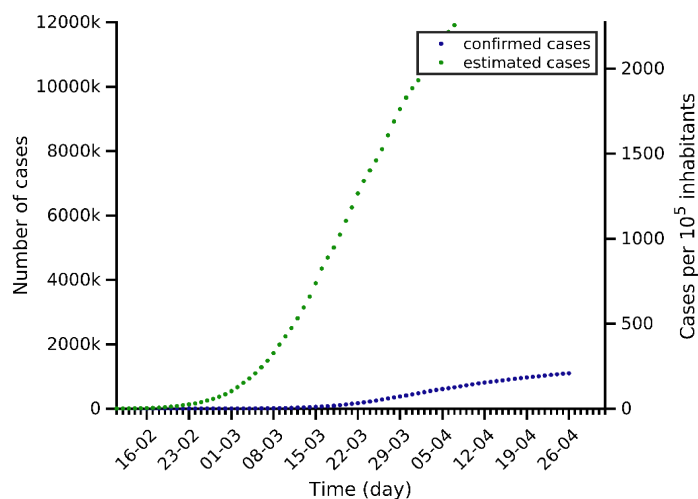
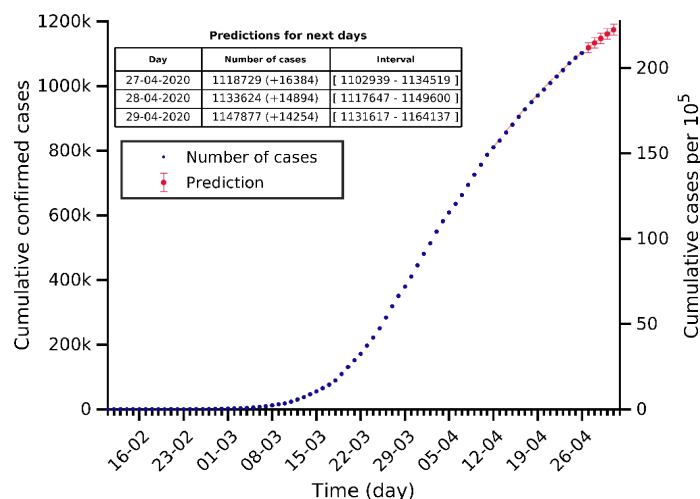


Deaths /  
cumulated  
reported cases

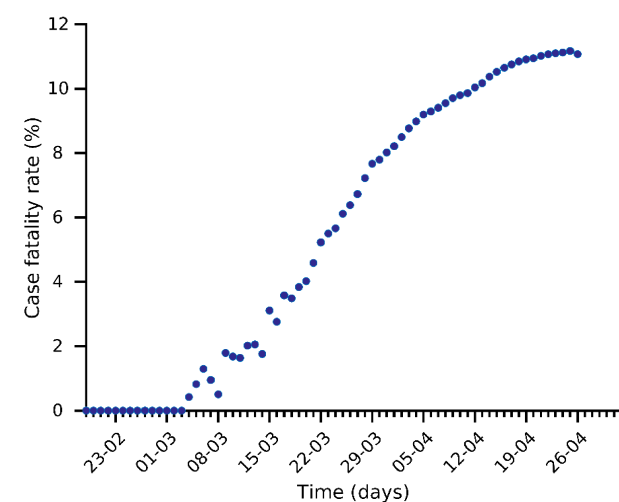
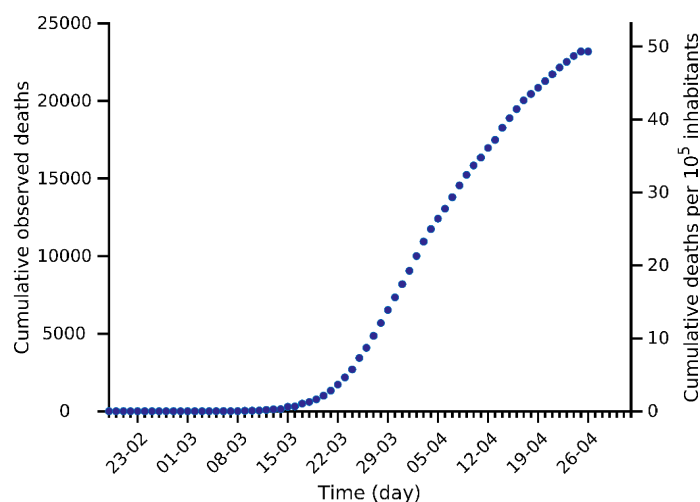
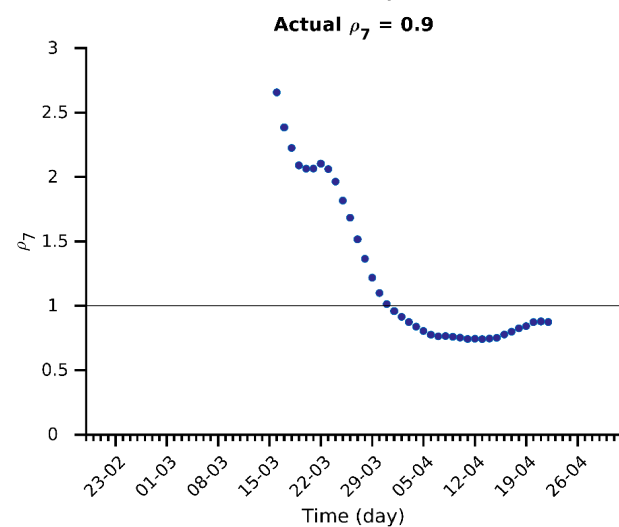
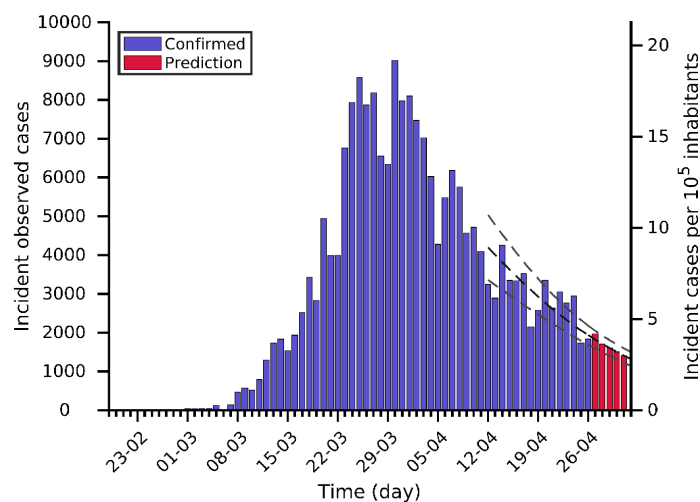
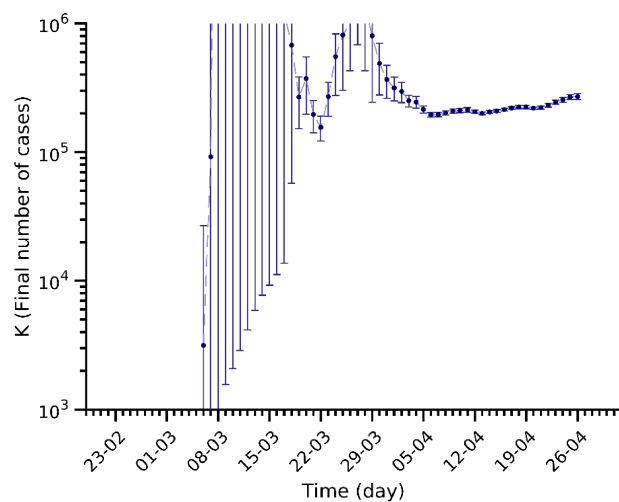
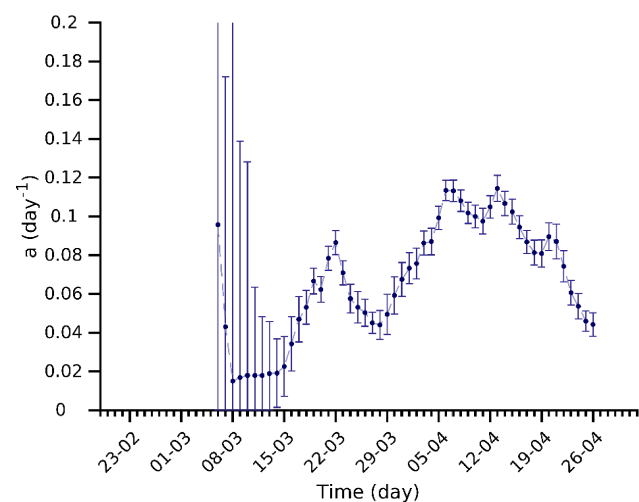
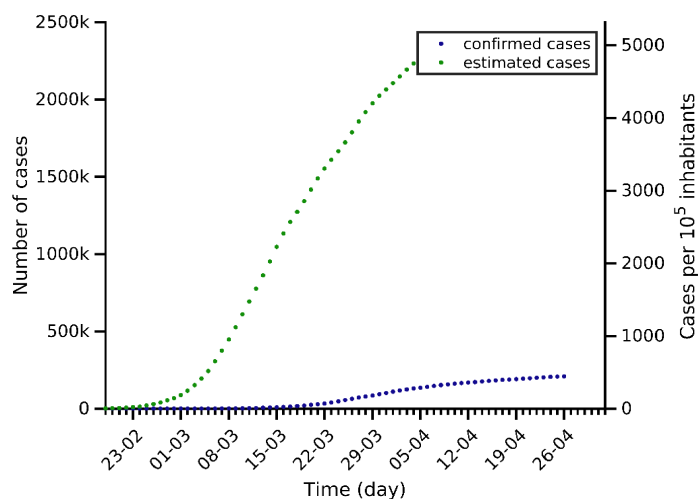
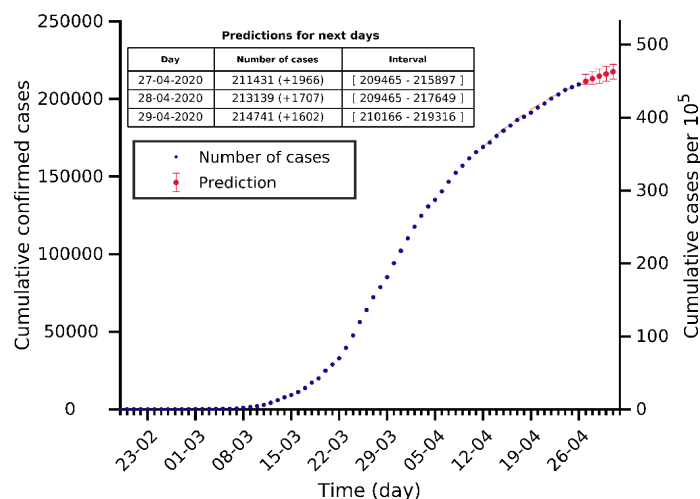


## **(1) Analysis and prediction of COVID-19 for EU+EFTA+UK**

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

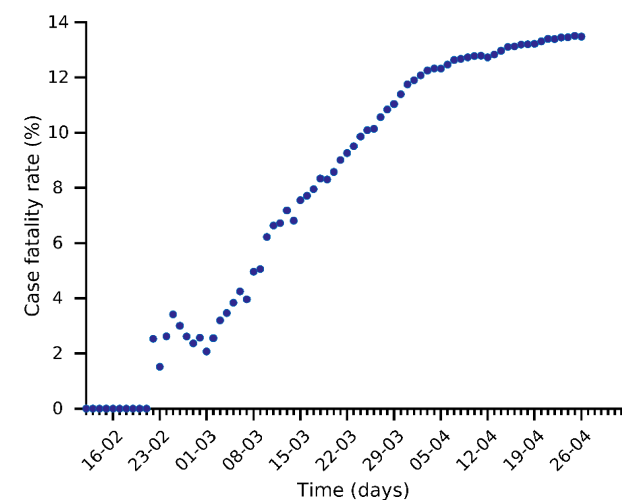
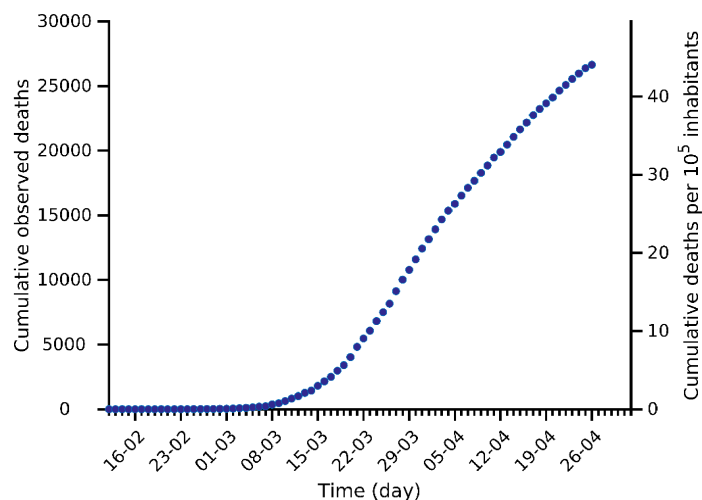
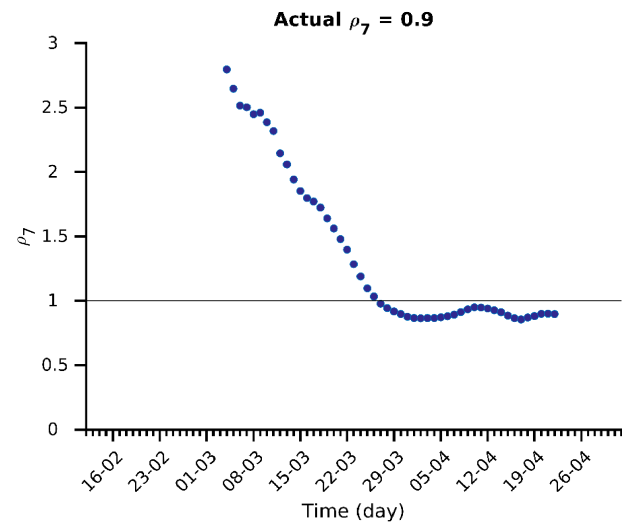
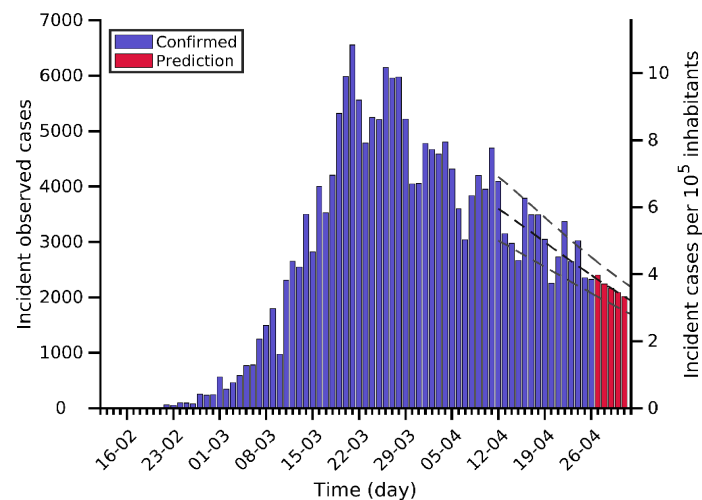
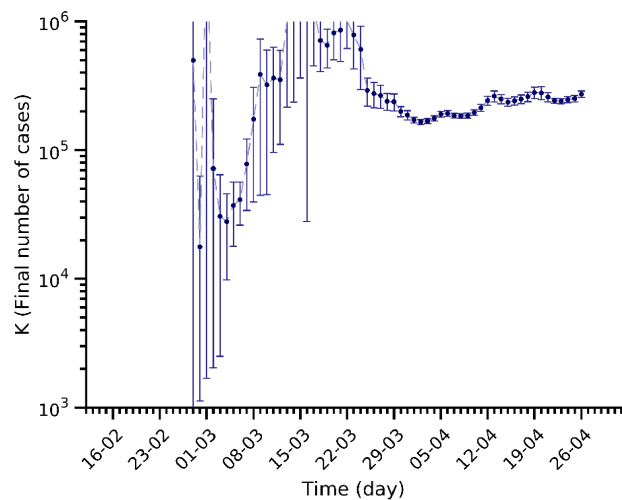
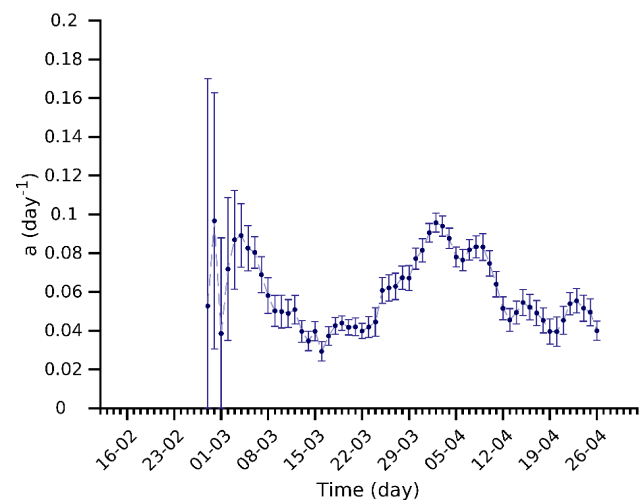
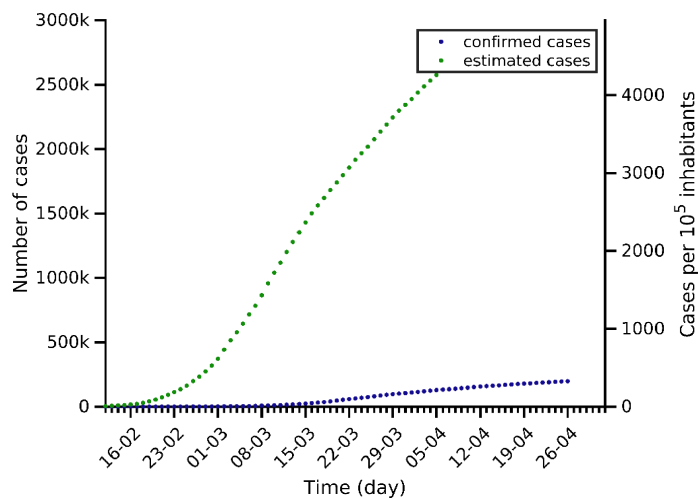
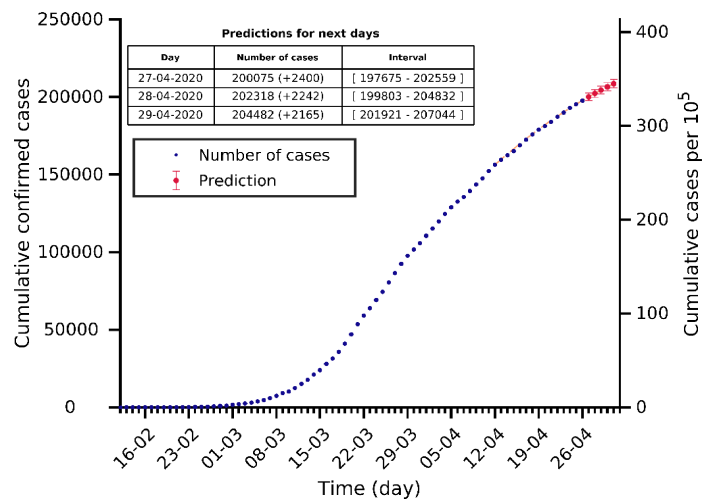


# Spain 26-04-2020. Population: 47.0M. Current cumulated incidence: 445/10<sup>5</sup>

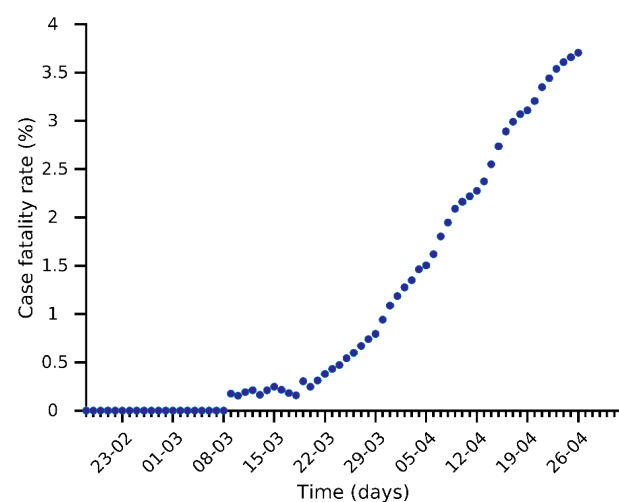
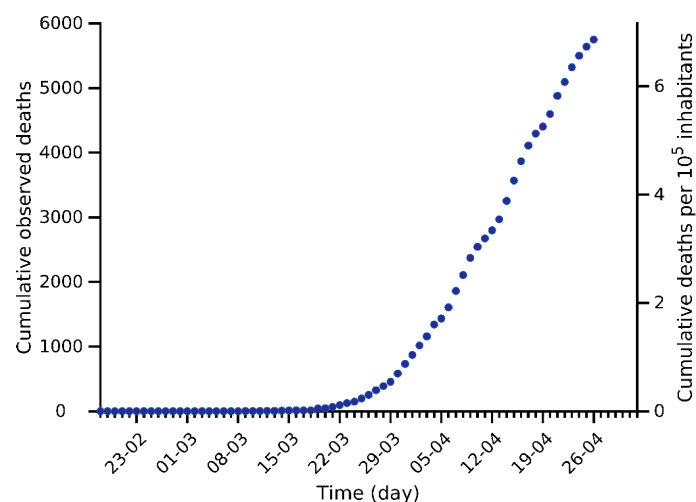
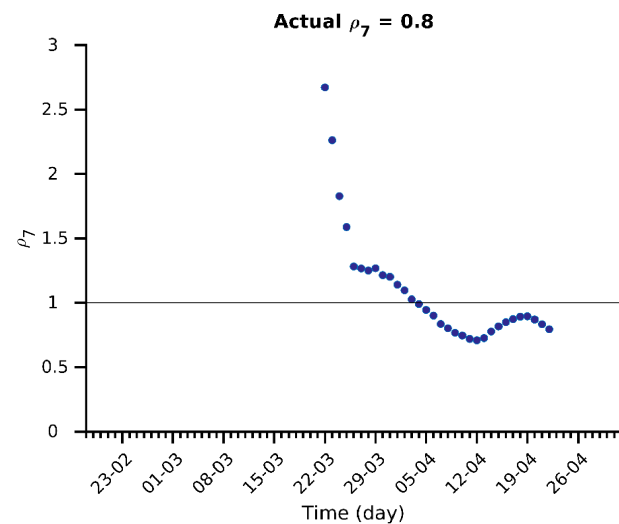
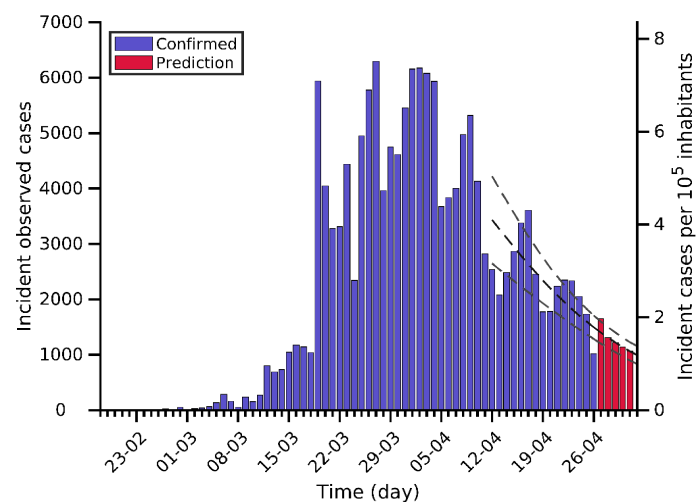
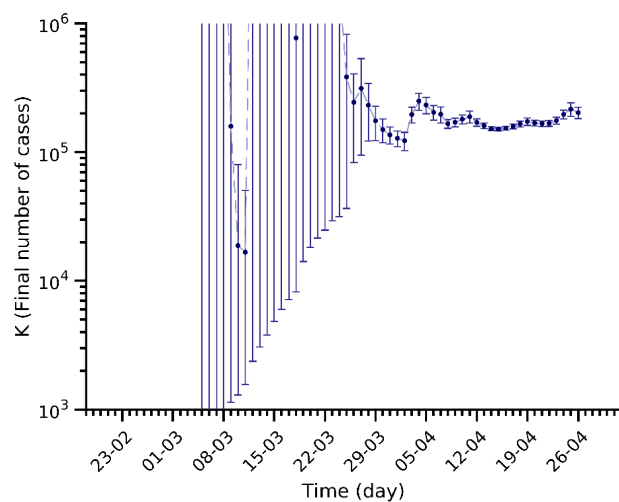
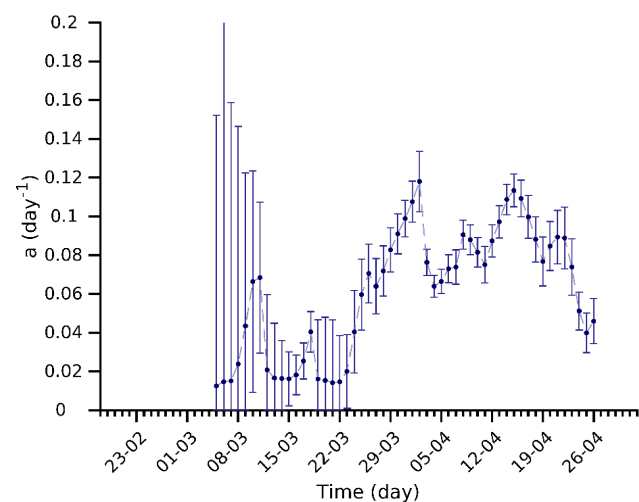
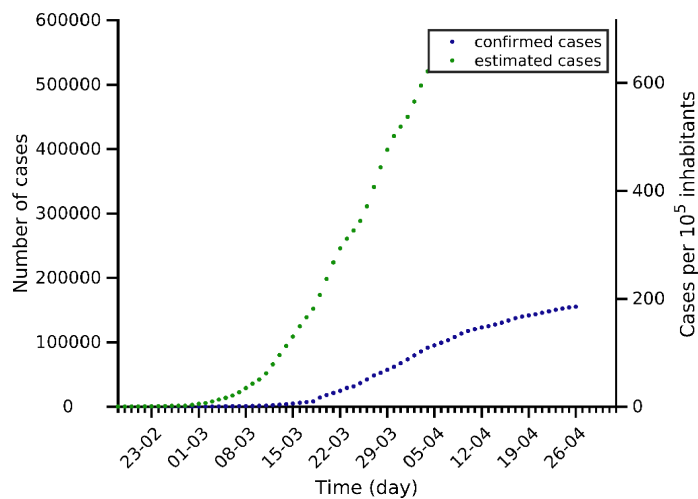
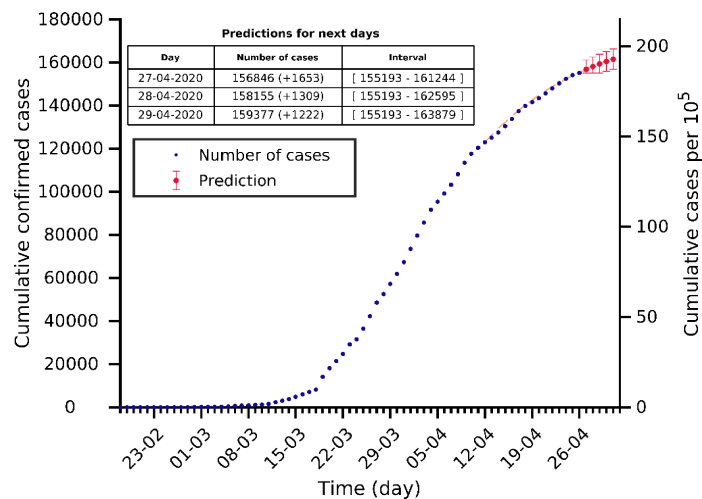




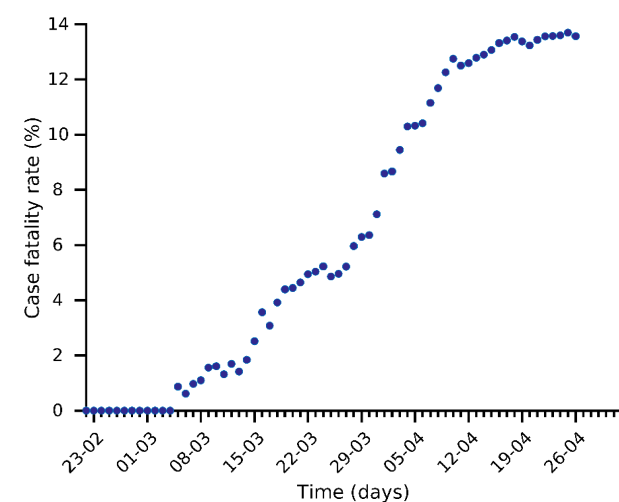
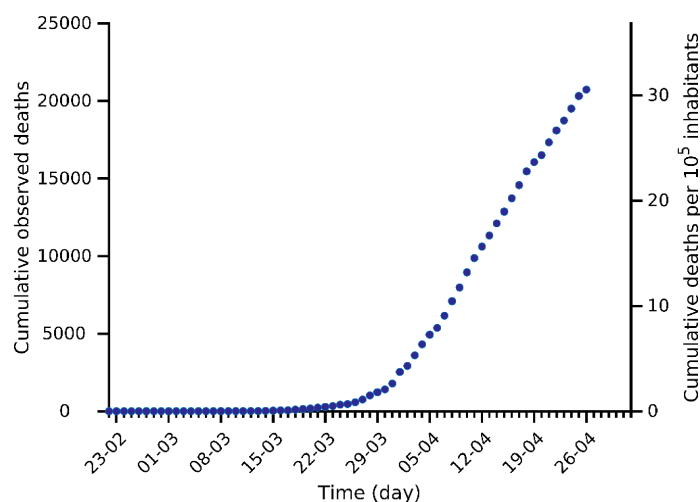
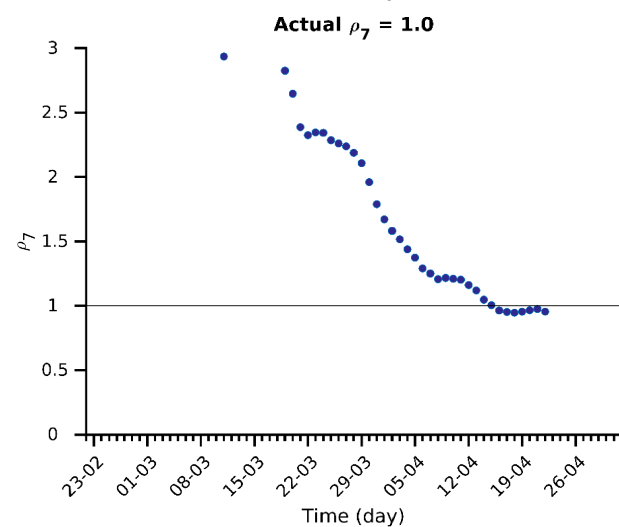
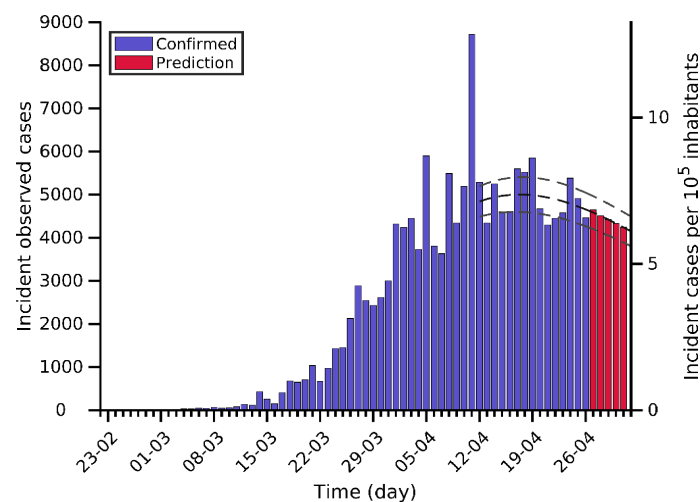
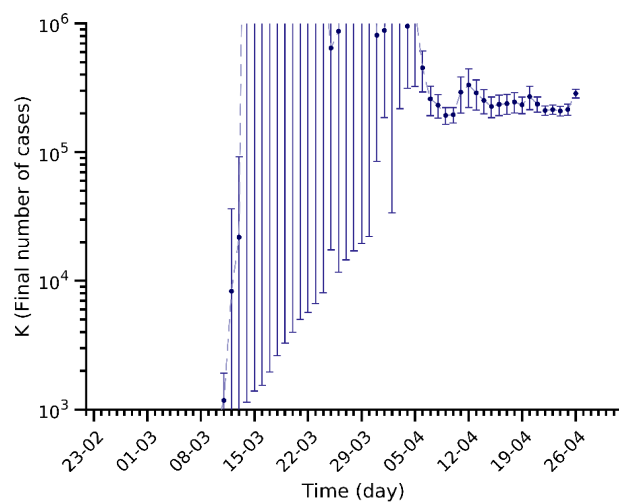
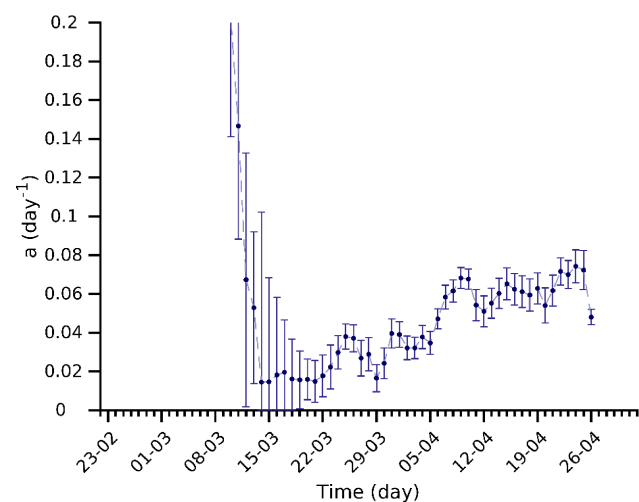
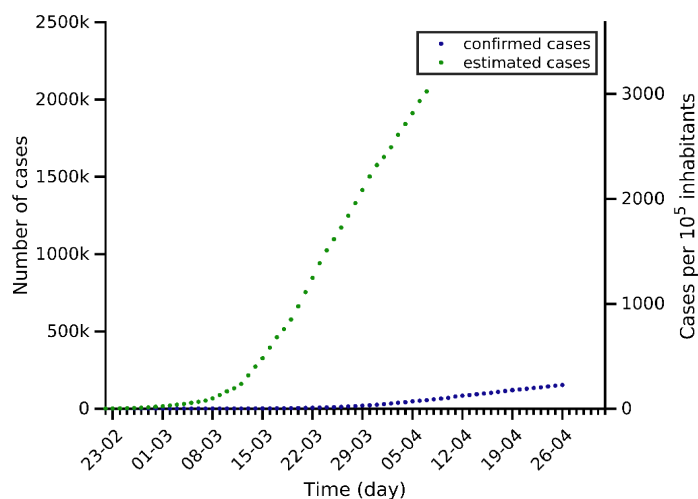
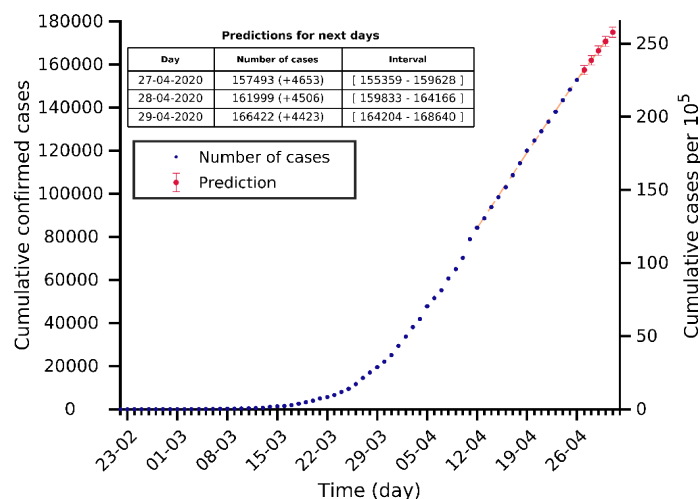
# Italy 26-04-2020. Population: 60.5M. Current cumulated incidence: 327/10<sup>5</sup>



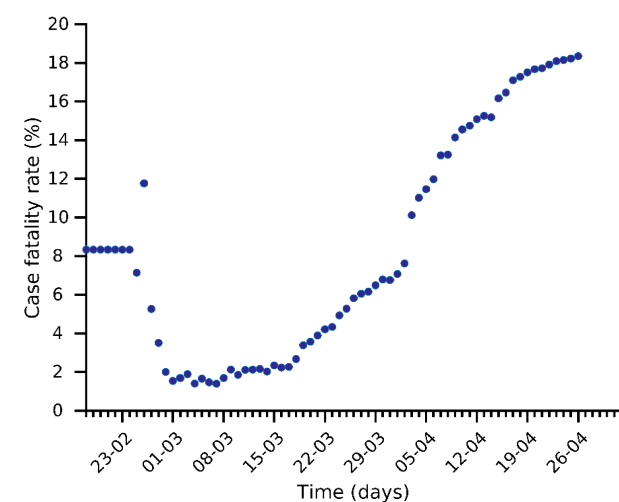
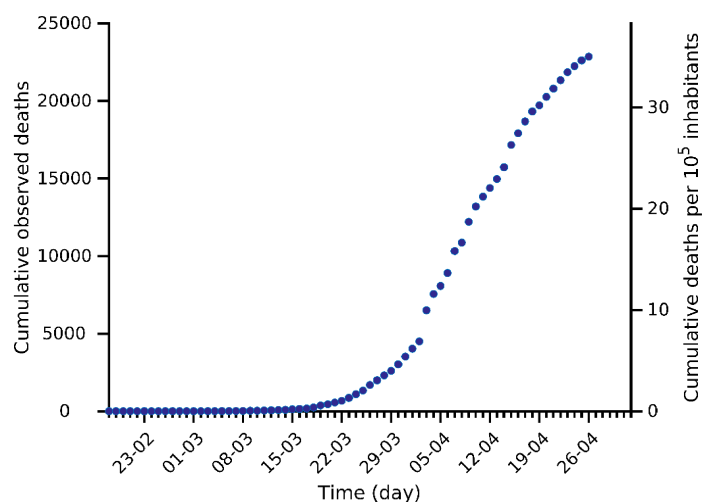
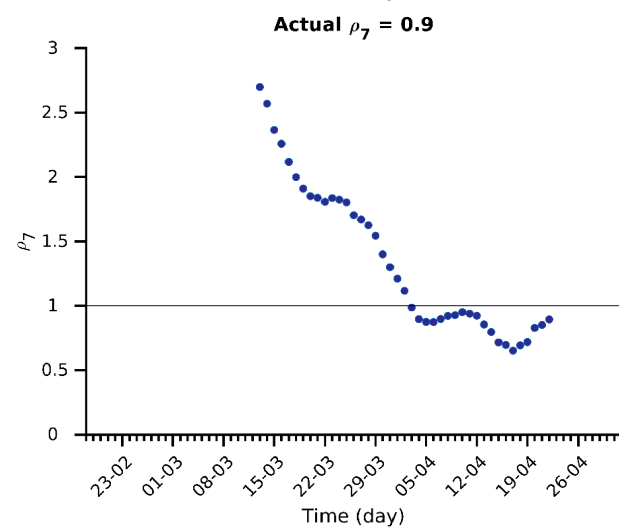
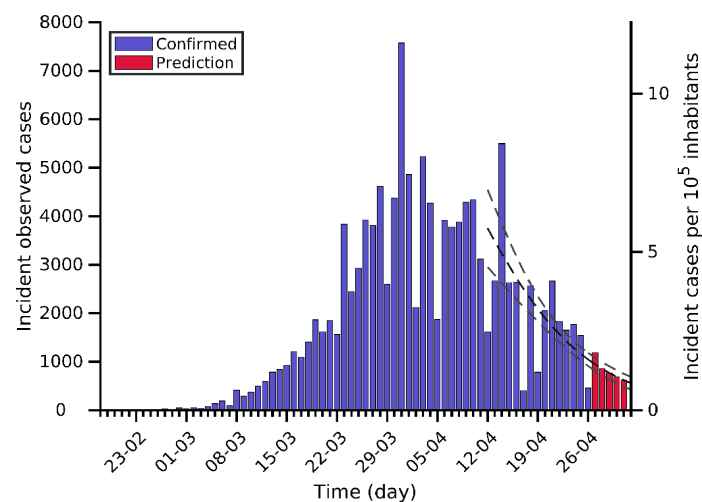
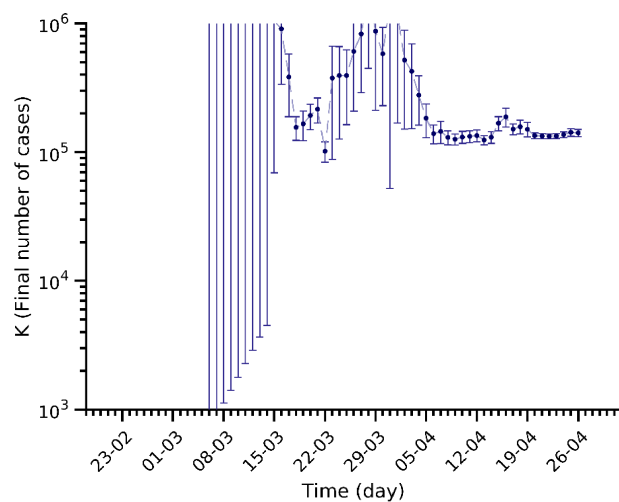
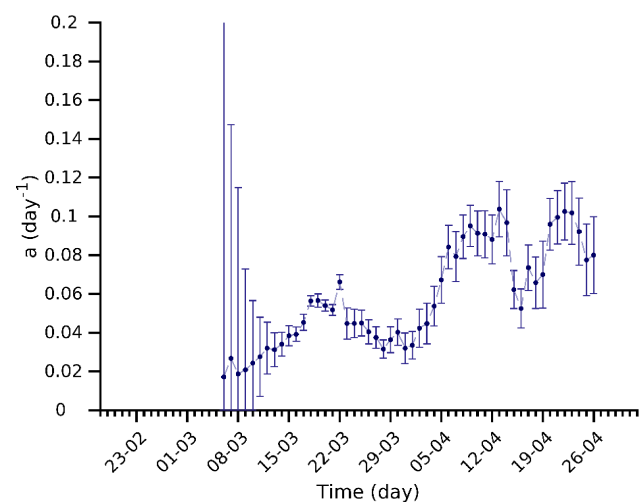
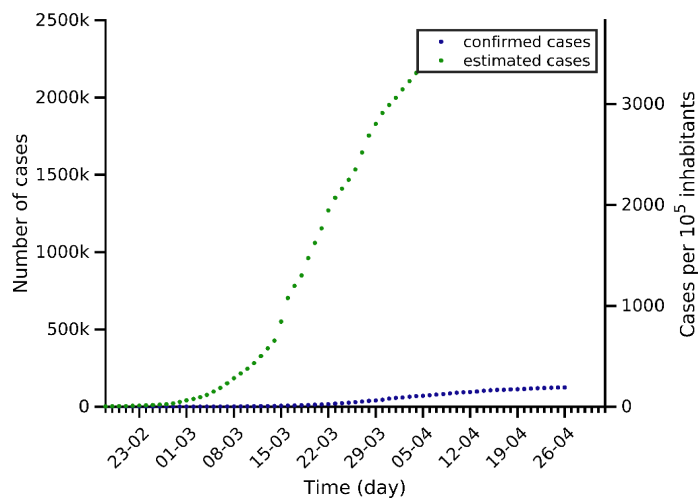
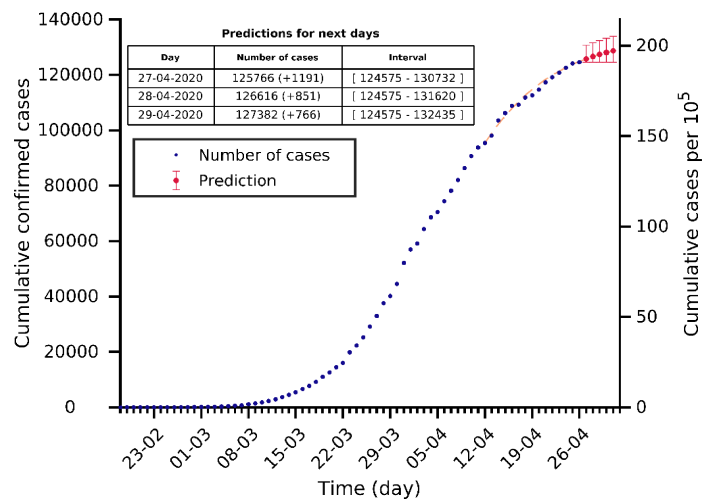
# Germany 26-04-2020. Population: 83.8M. Current cumulated incidence: 185/10<sup>5</sup>



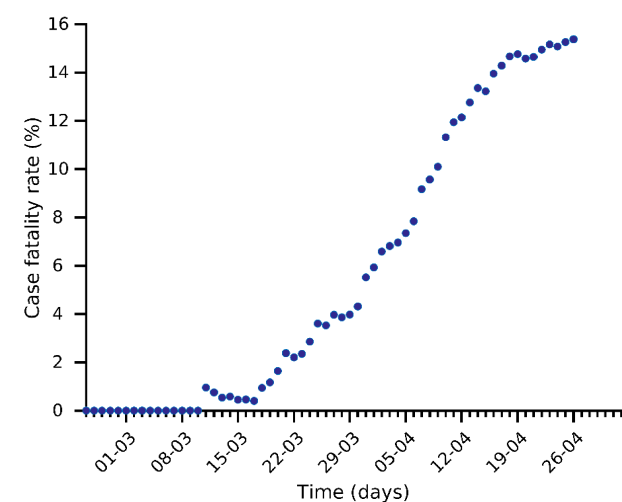
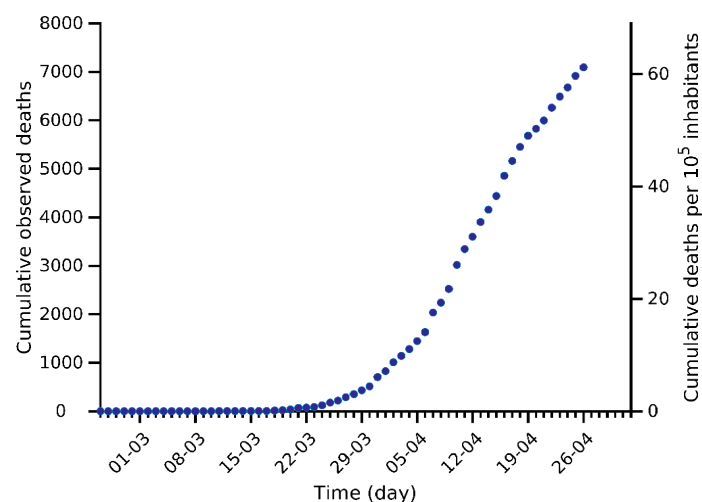
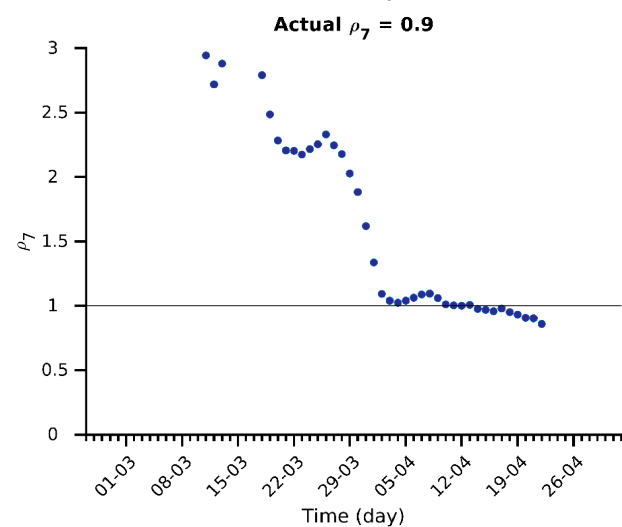
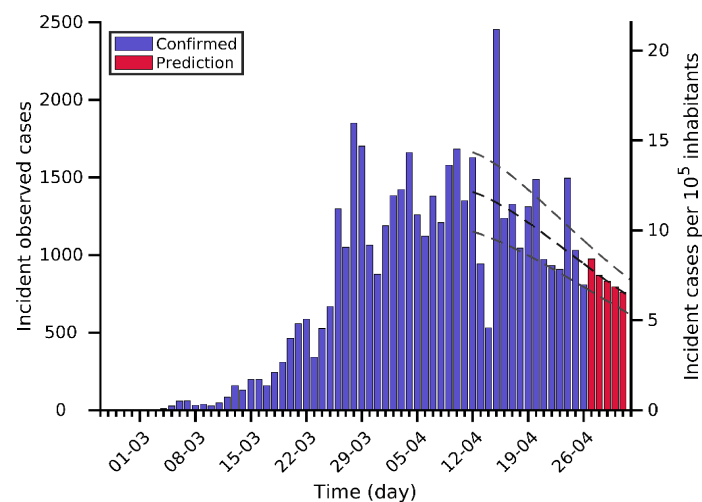
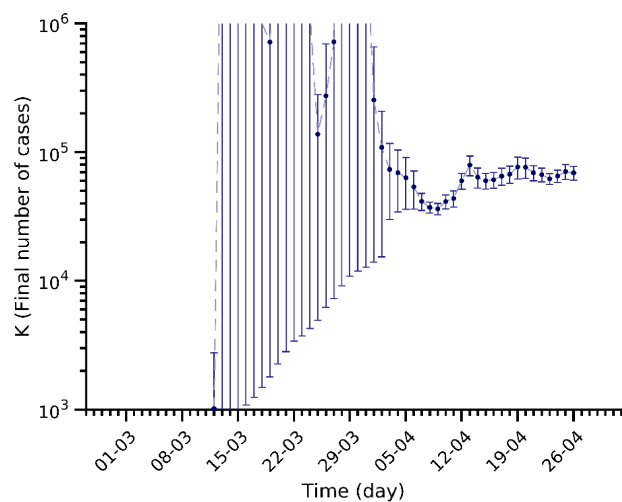
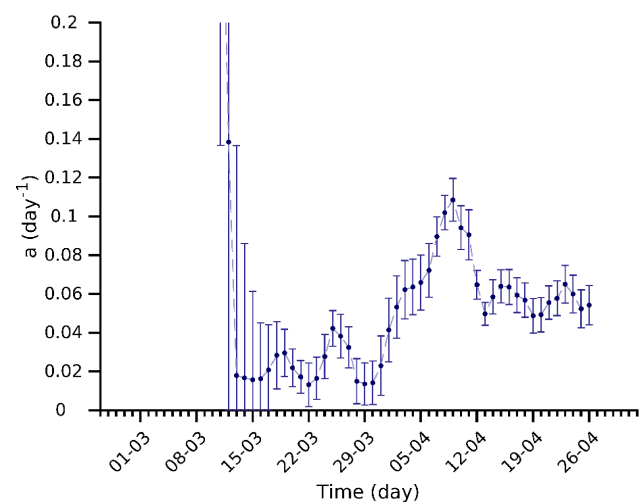
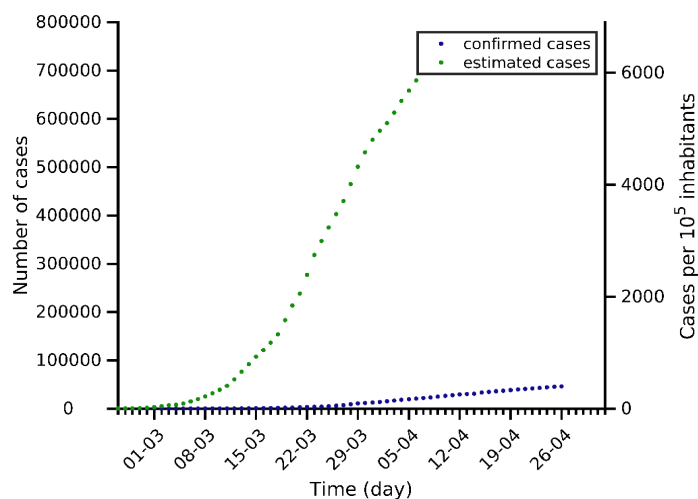
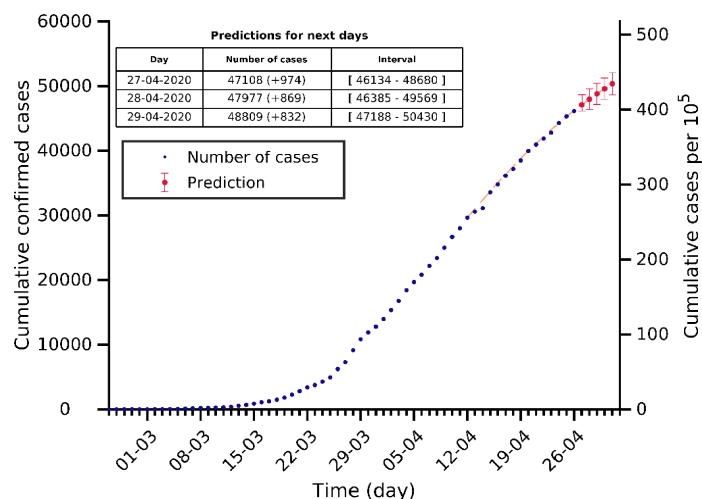
# UK 26-04-2020. Population: 67.9M. Current cumulated incidence: 225/10<sup>5</sup>



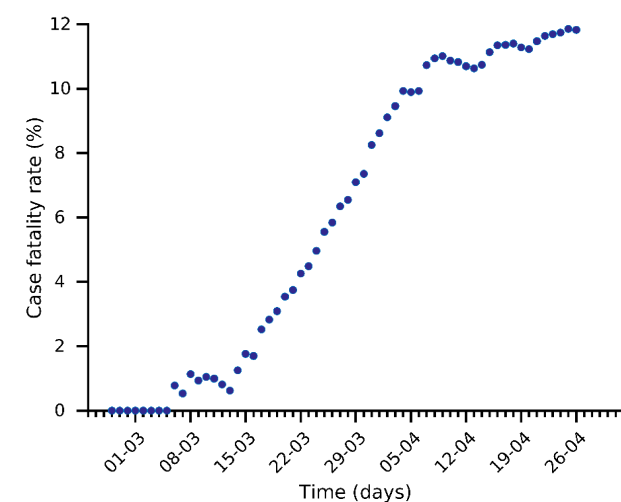
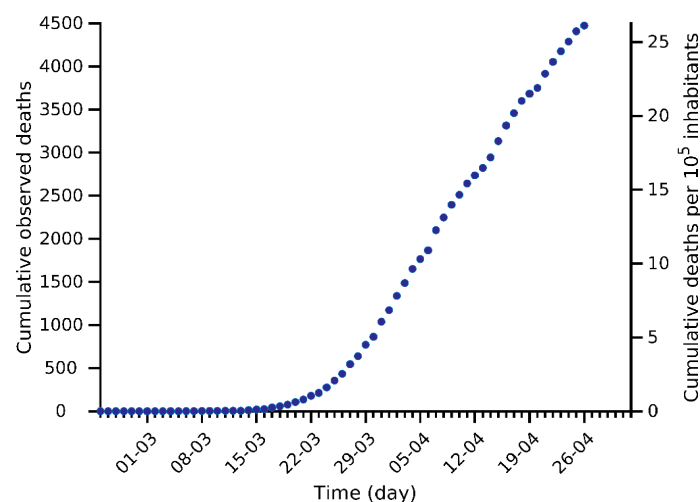
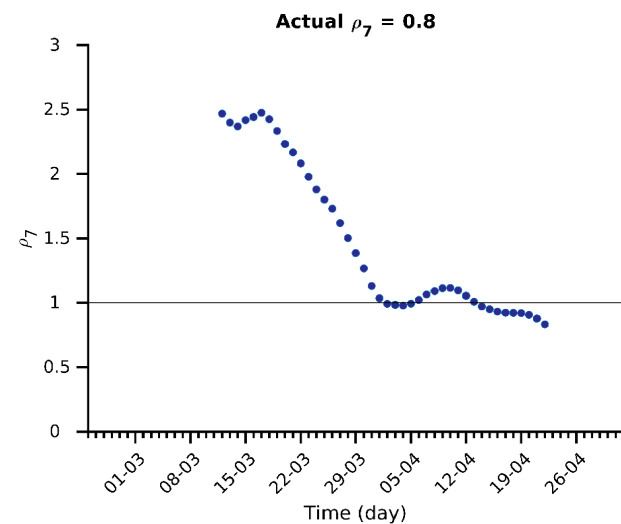
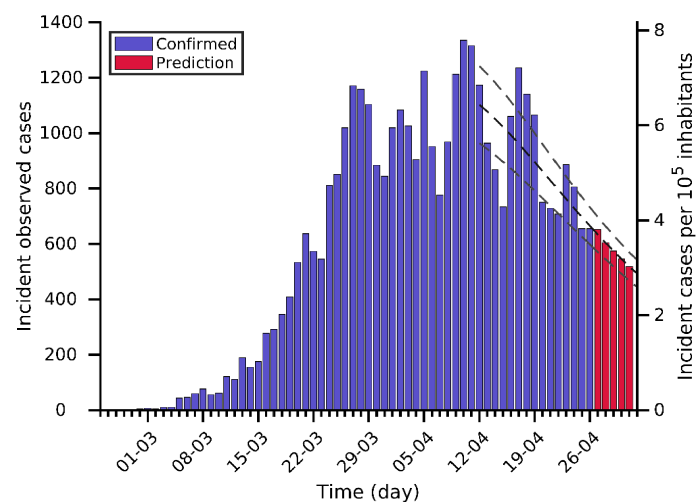
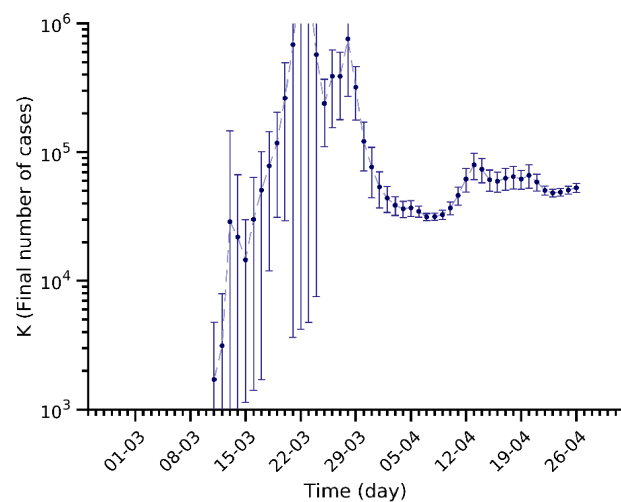
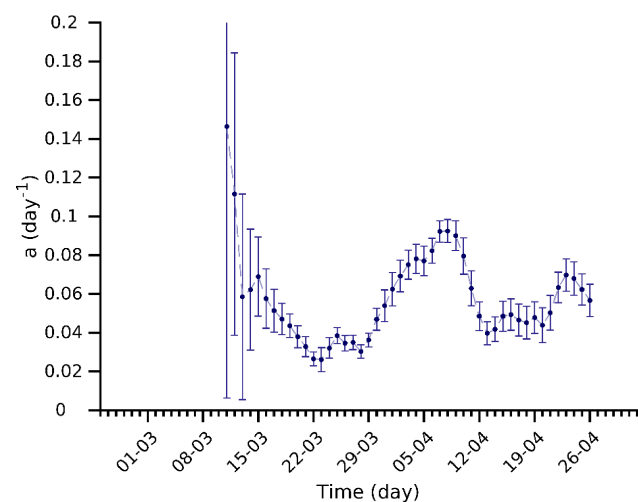
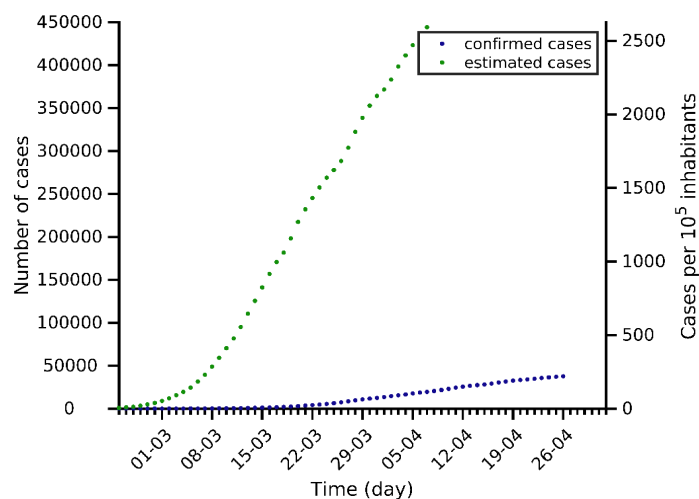
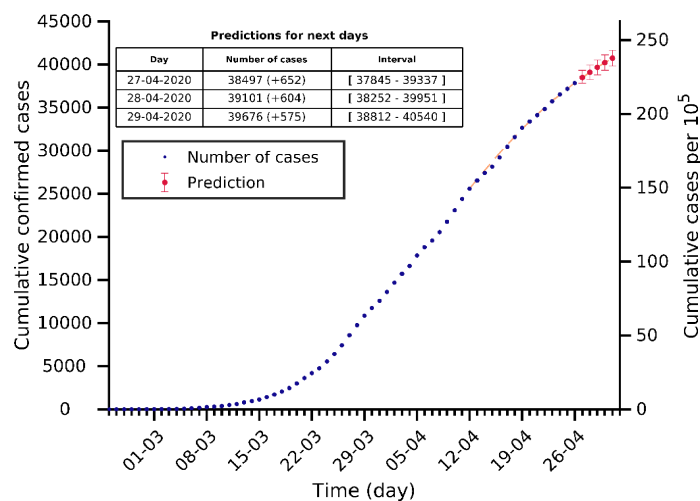
# France 26-04-2020. Population: 65.3M. Current cumulated incidence: 191/10<sup>5</sup>



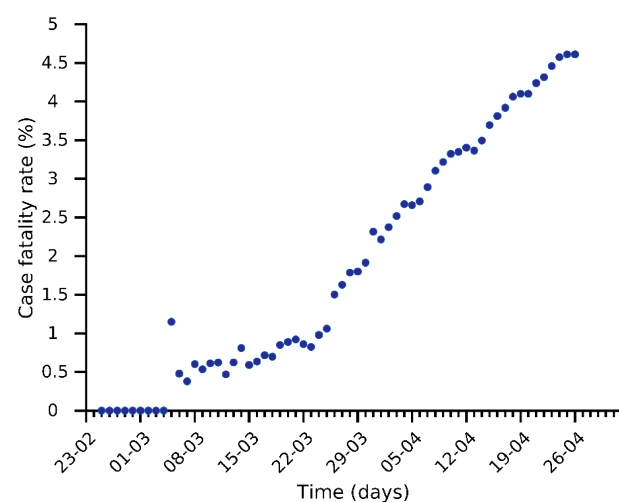
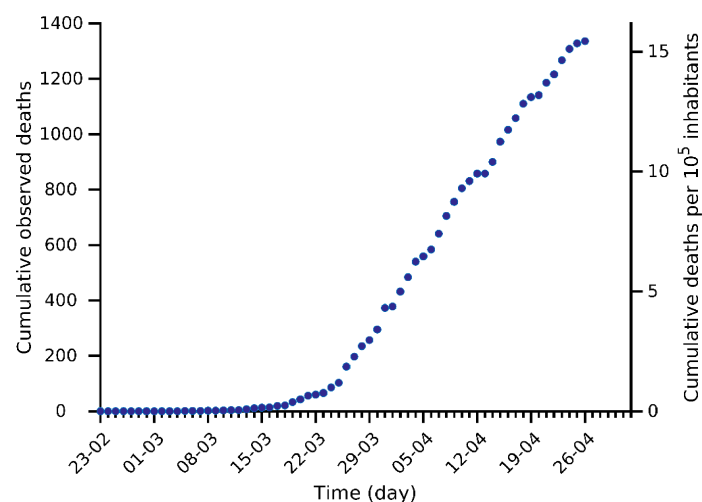
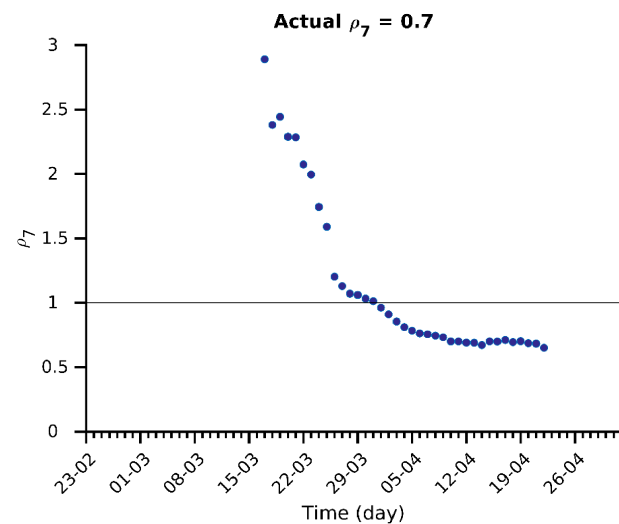
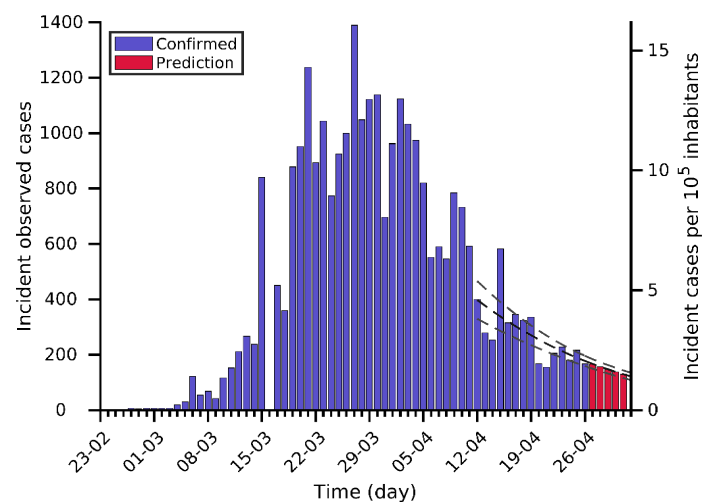
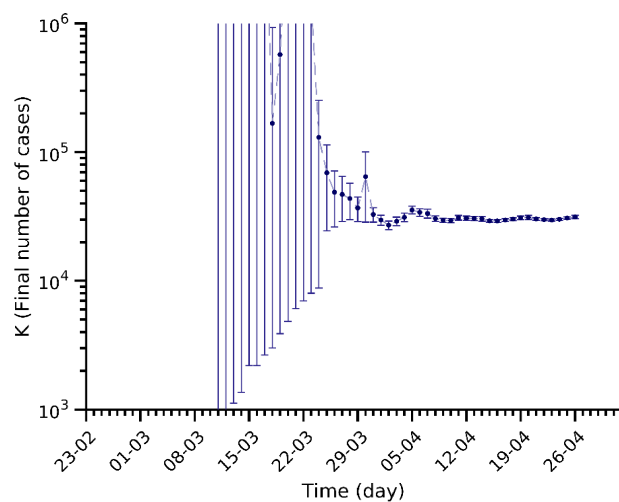
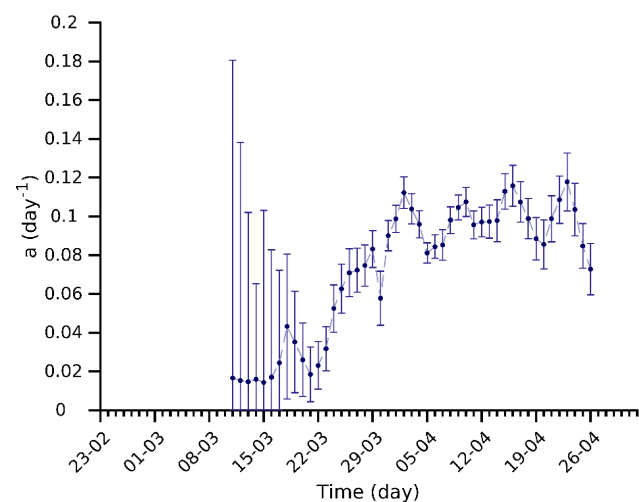
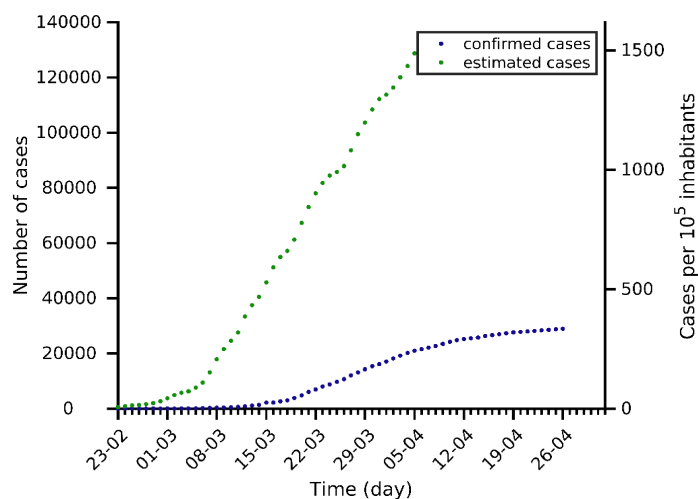
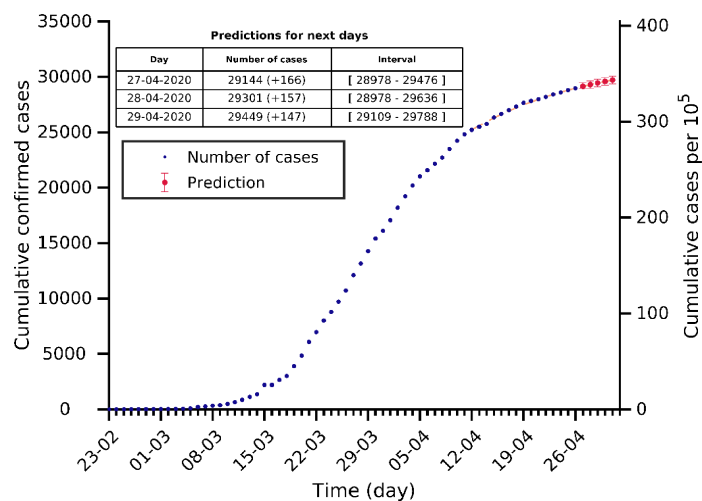
# Belgium 26-04-2020. Population: 11.6M. Current cumulated incidence: 398/10<sup>5</sup>



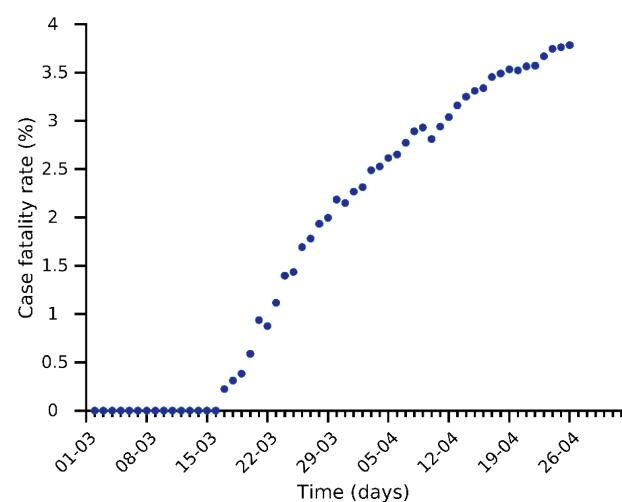
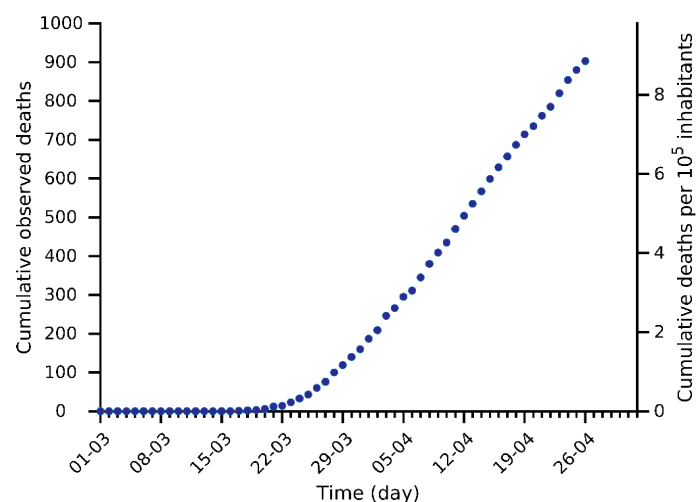
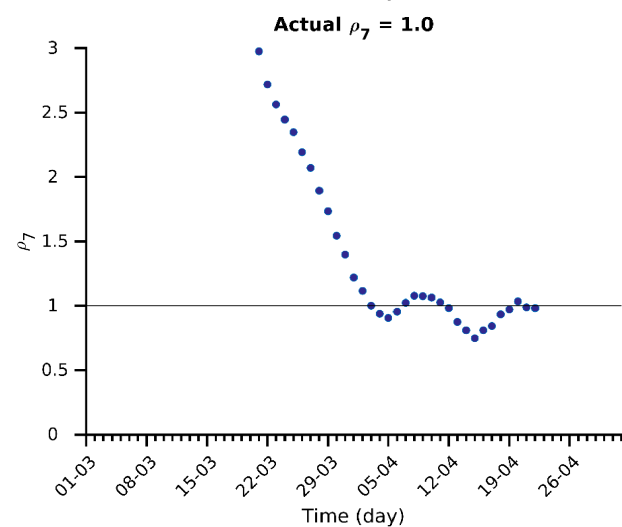
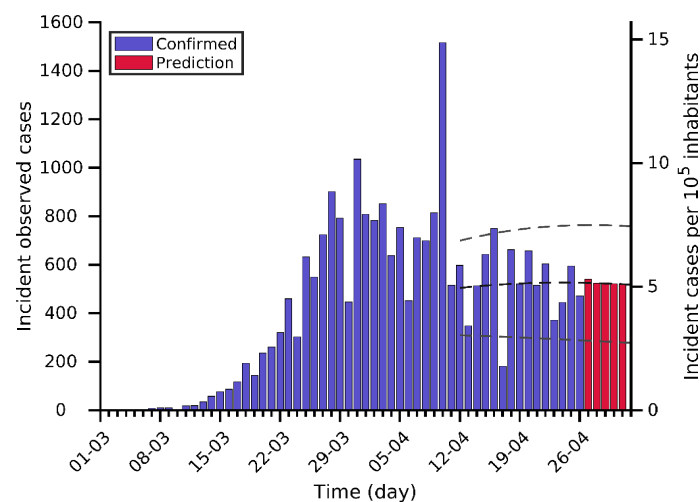
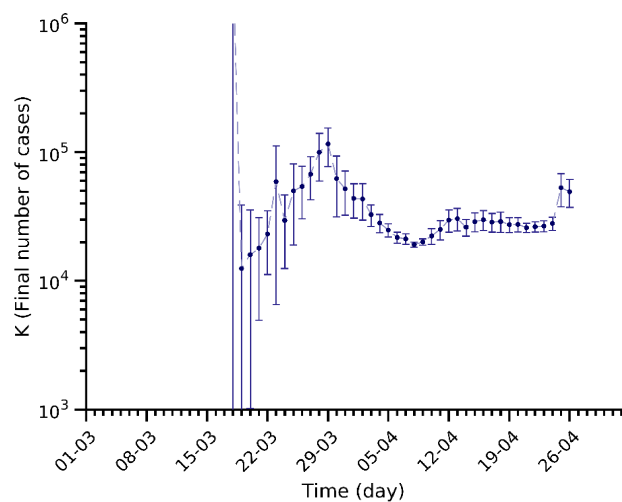
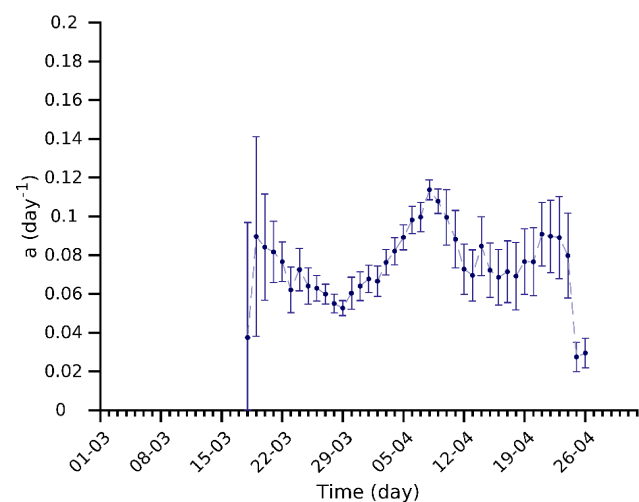
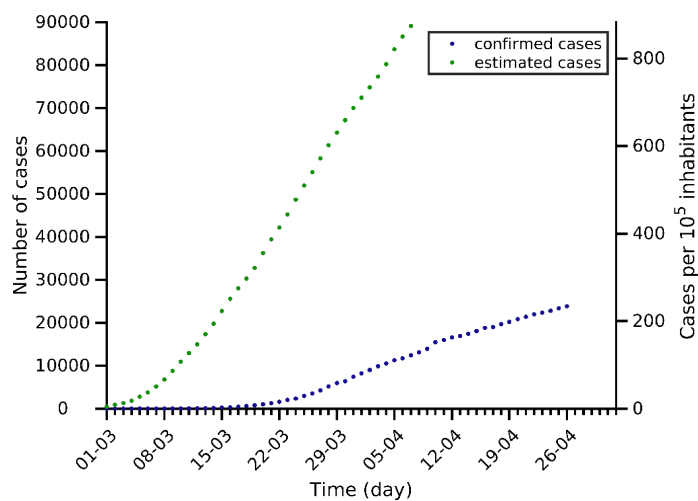
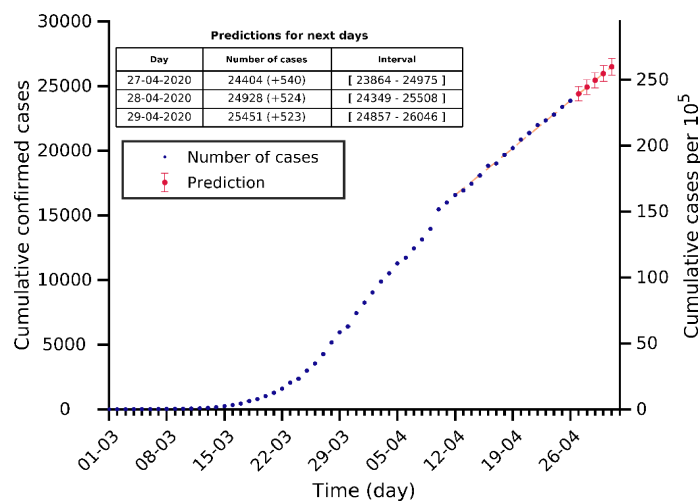
# Netherlands 26-04-2020. Population: 17.1M. Current cumulated incidence: 221/10<sup>5</sup>



# Switzerland 26-04-2020. Population: 8.7M. Current cumulated incidence: 335/10<sup>5</sup>

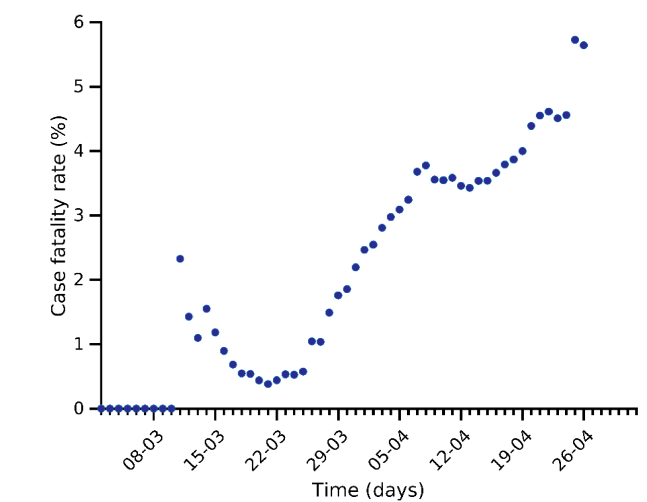
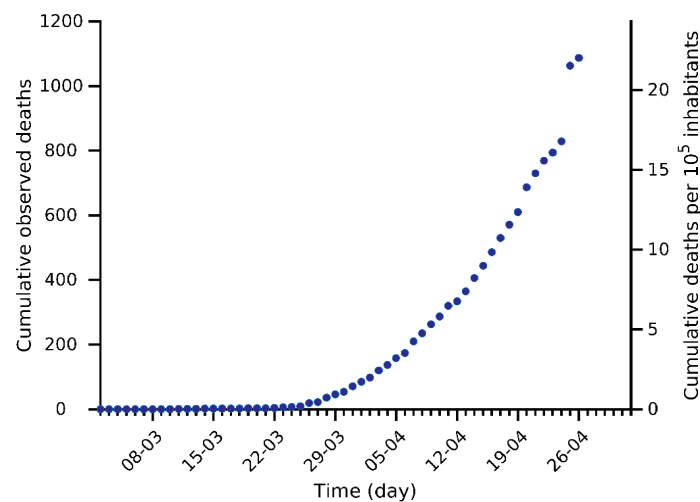
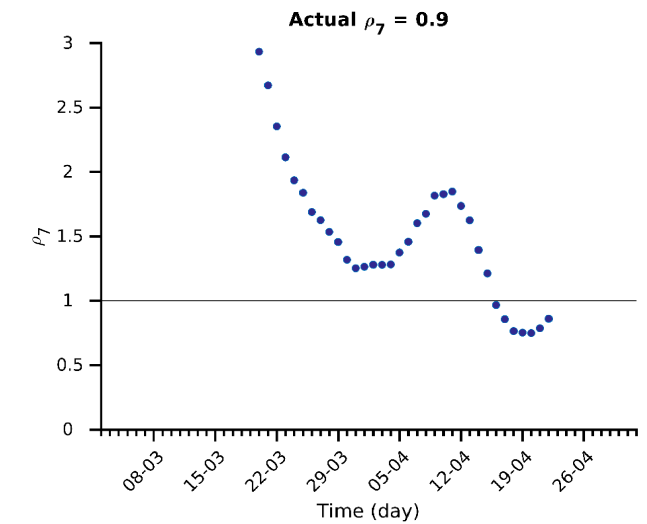
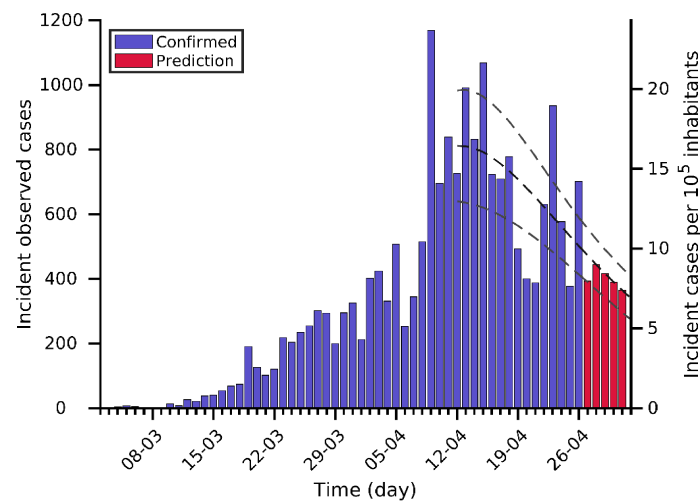
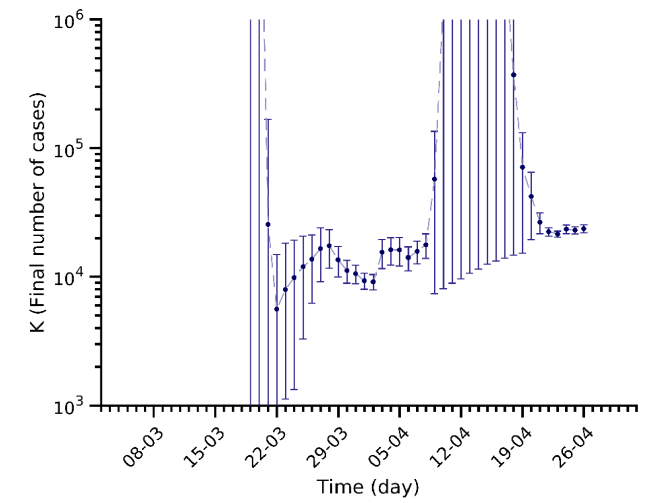
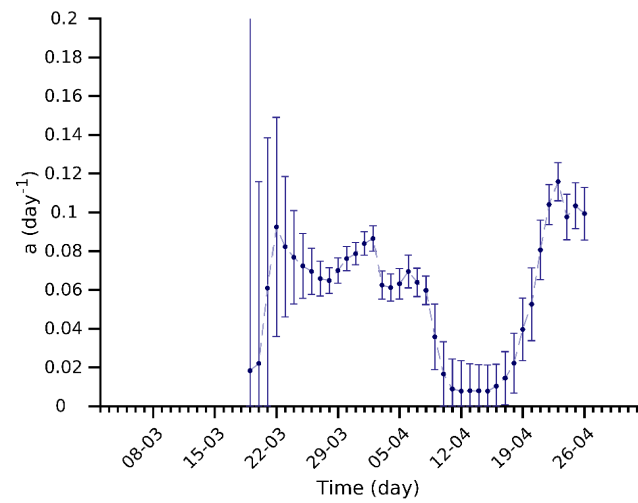
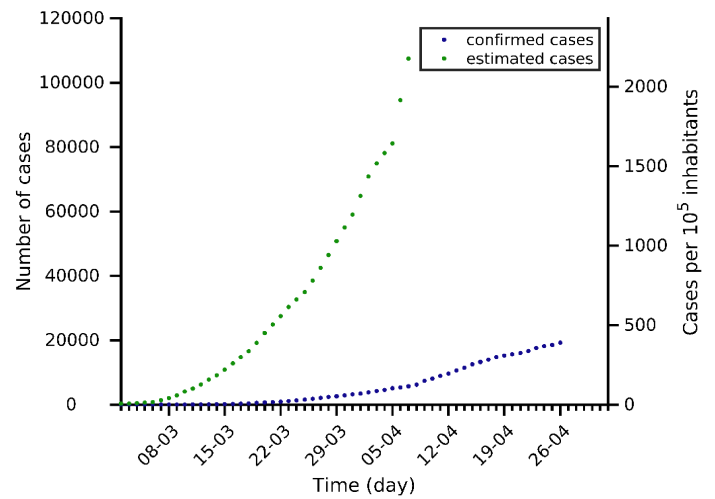
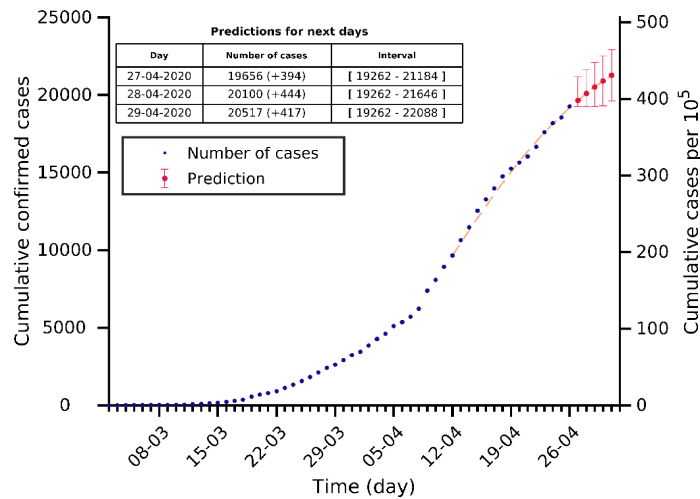


# Portugal 26-04-2020. Population: 10.2M. Current cumulated incidence: 234/10<sup>5</sup>

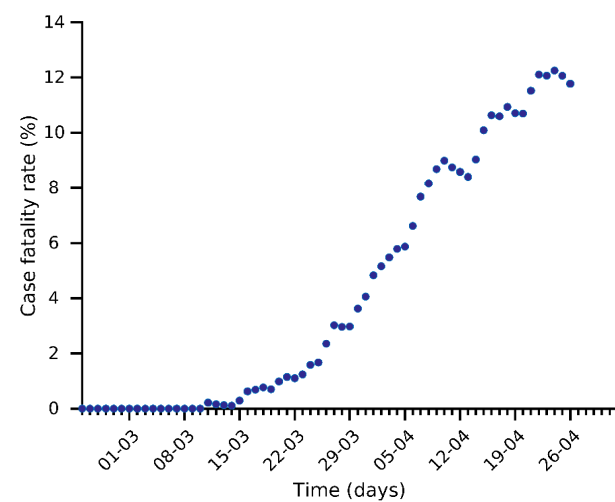
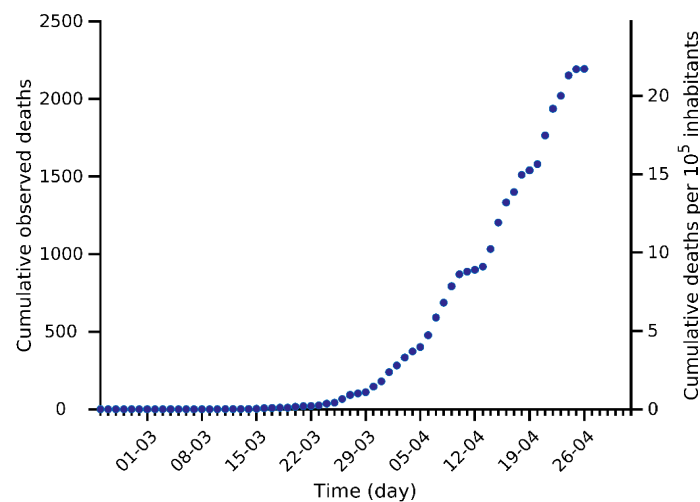
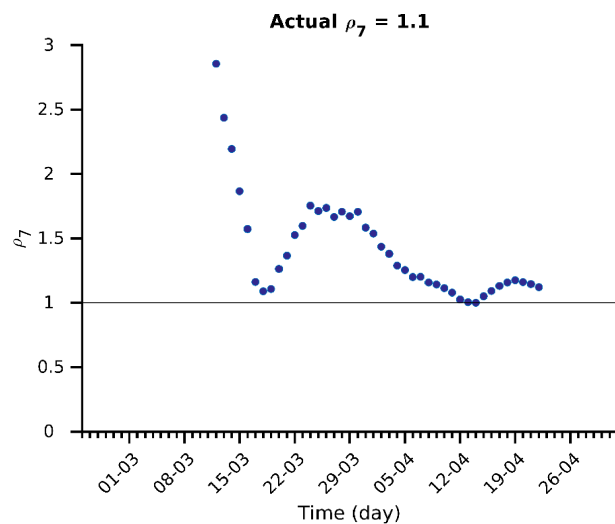
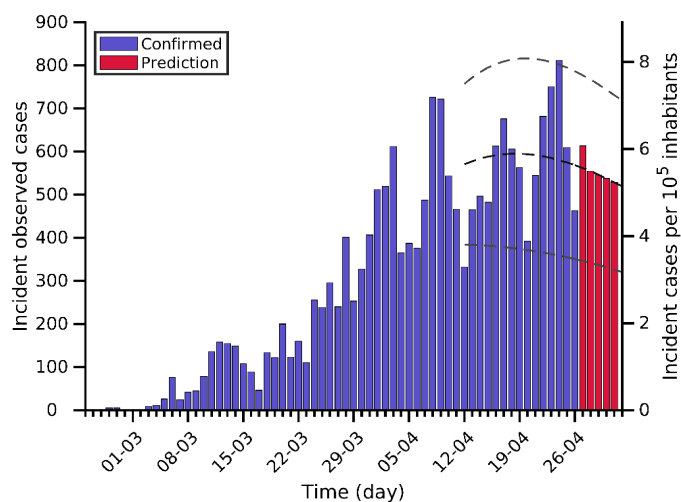
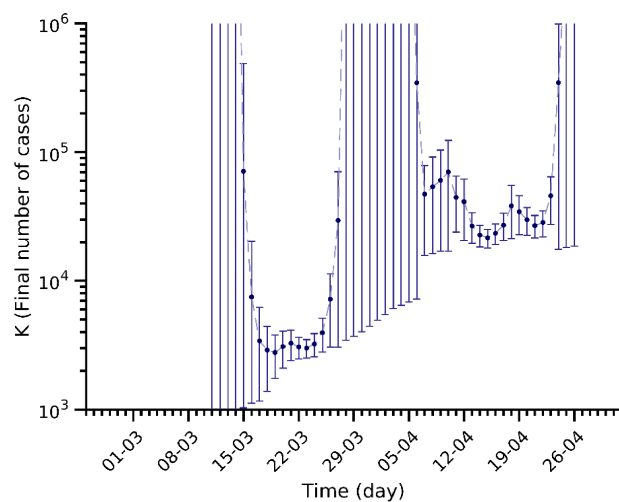
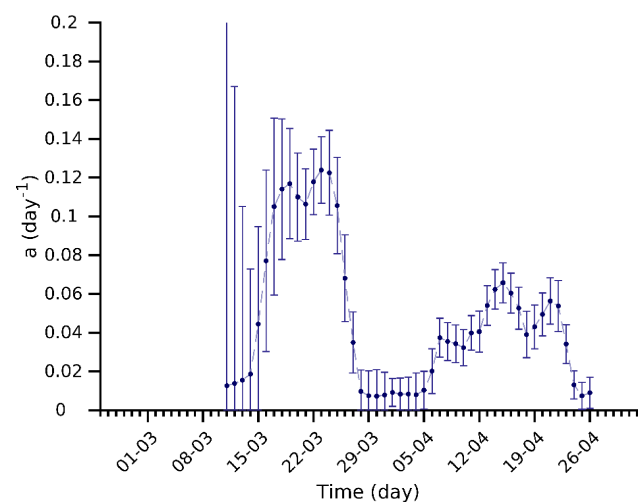
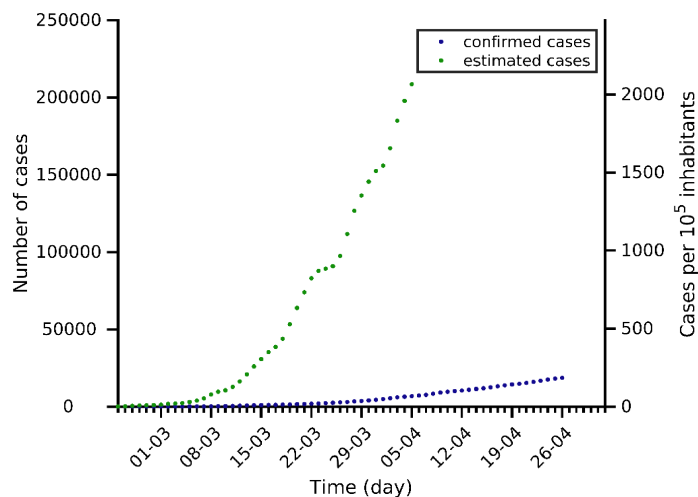
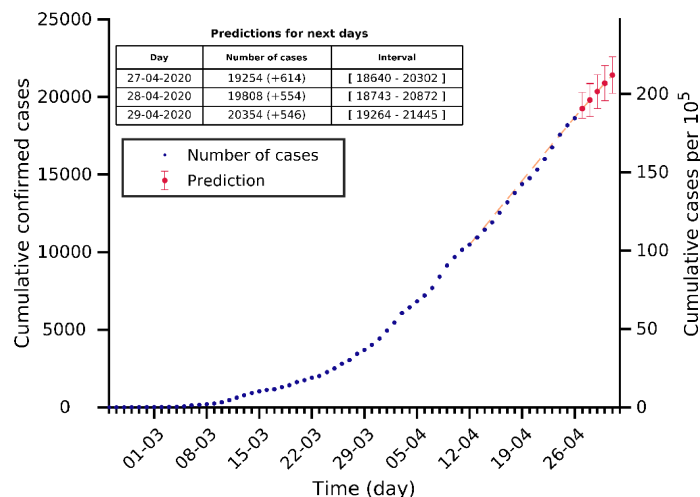




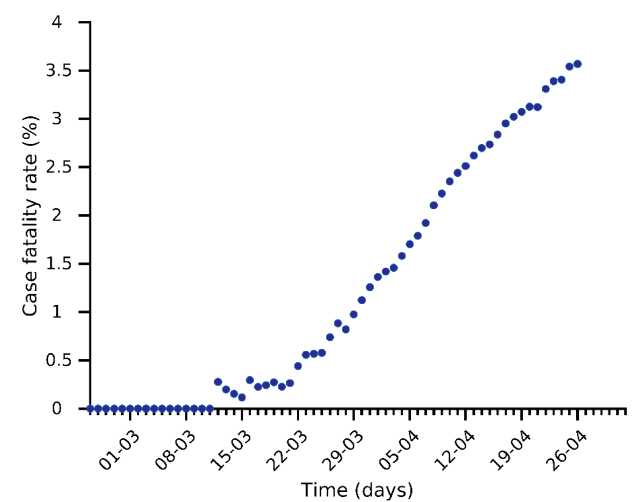
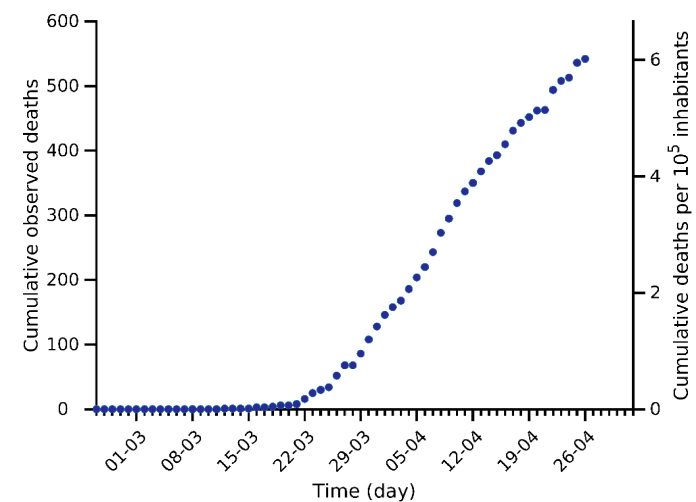
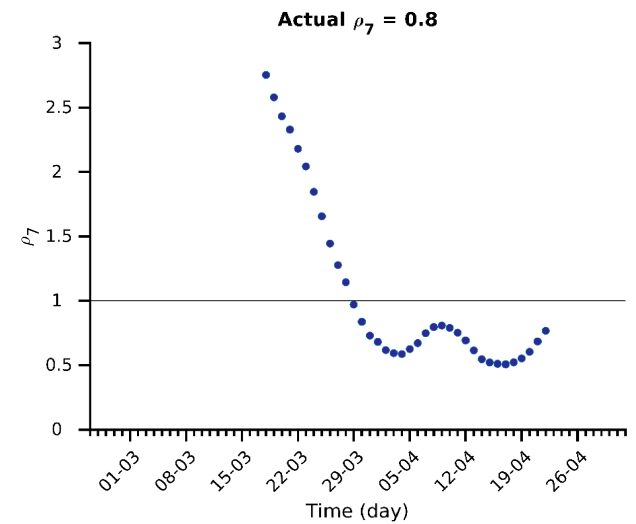
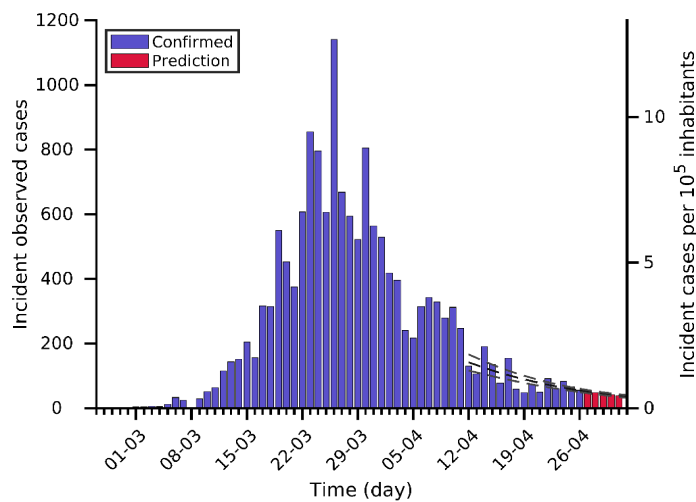
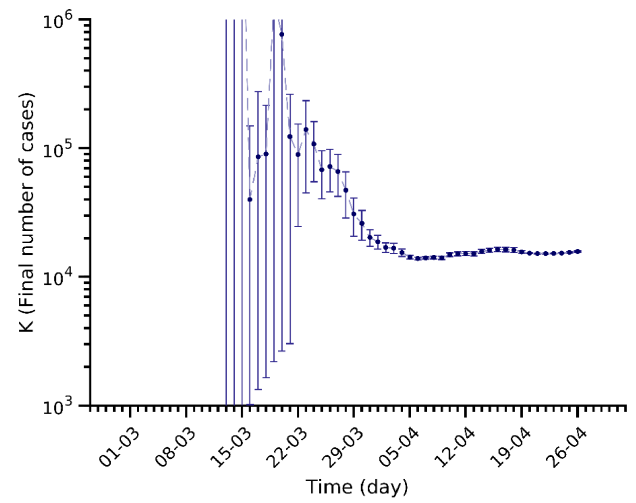
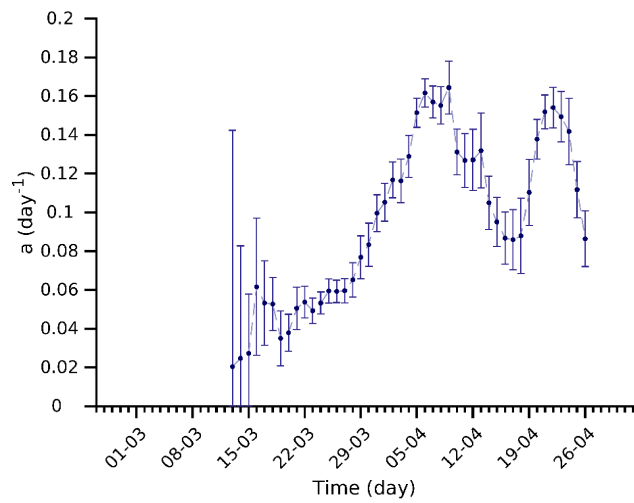
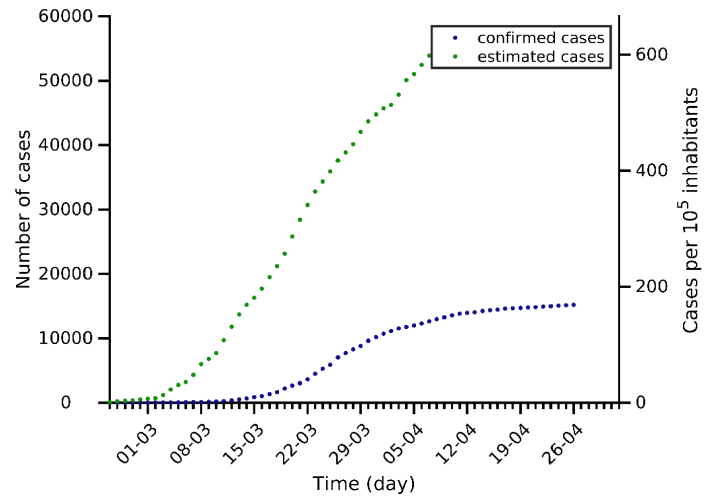
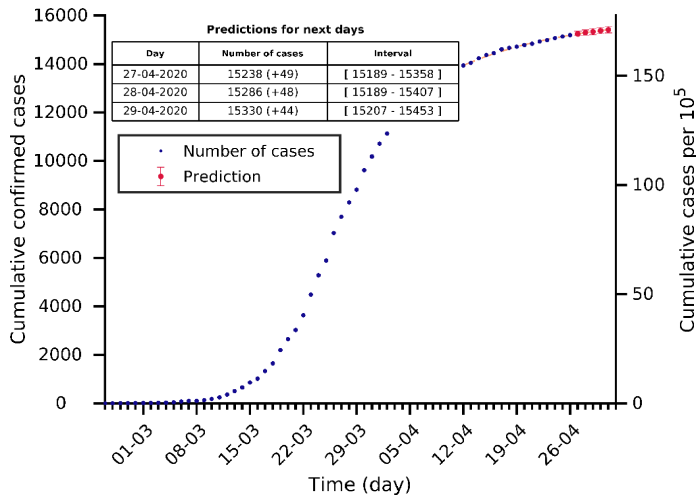
# Ireland 26-04-2020. Population: 4.9M. Current cumulated incidence: 390/10<sup>5</sup>



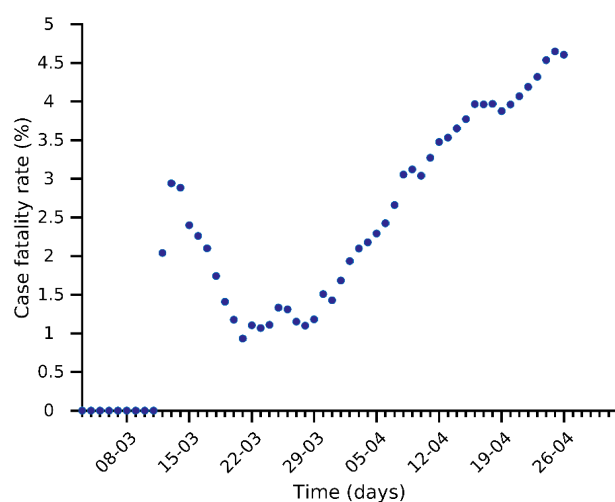
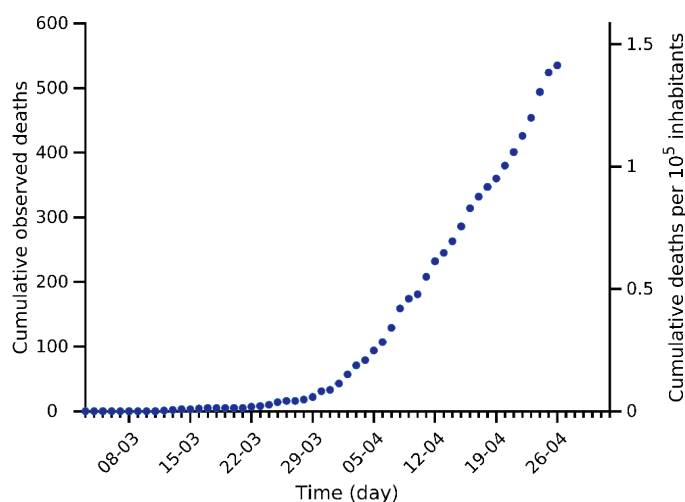
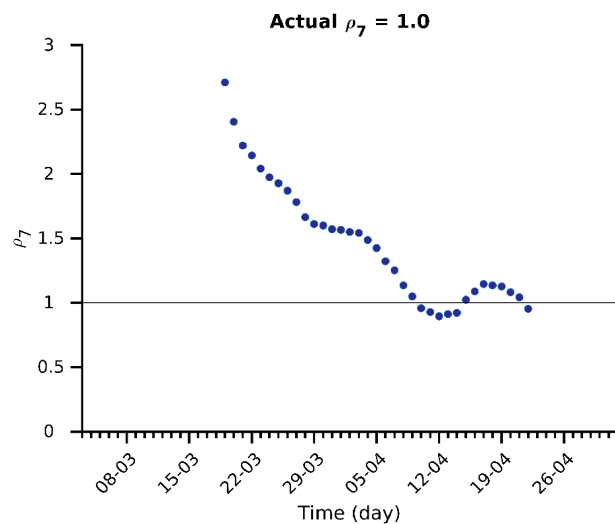
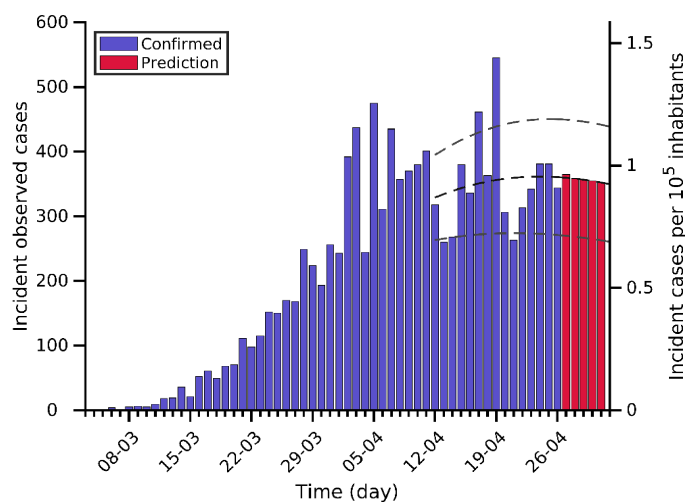
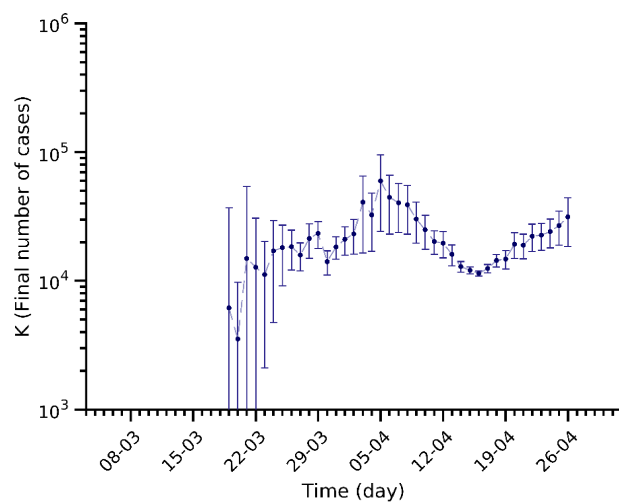
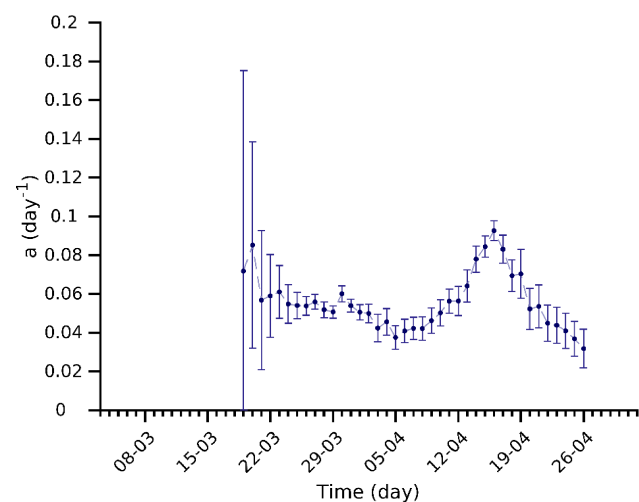
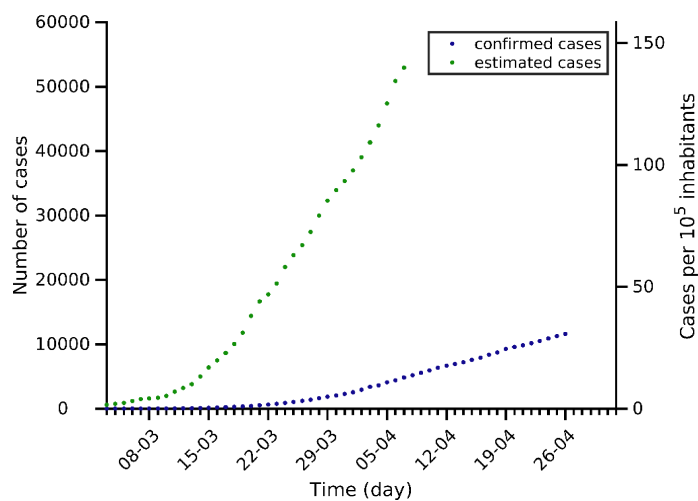
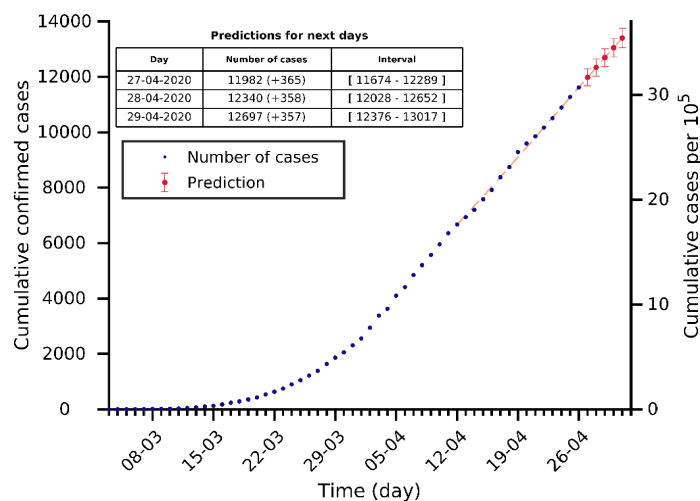
# Sweden 26-04-2020. Population: 10.1M. Current cumulated incidence: 185/10<sup>5</sup>



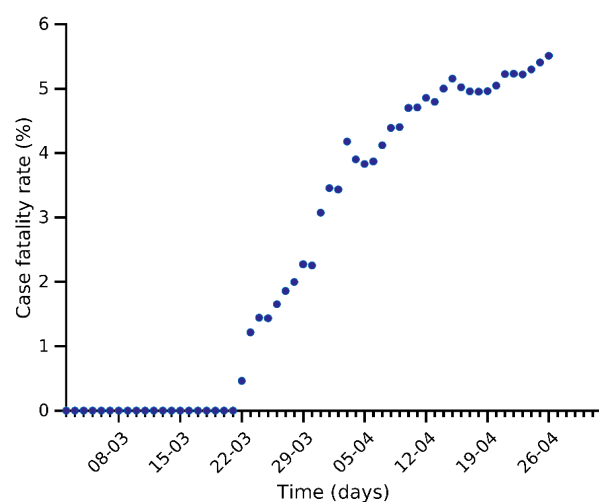
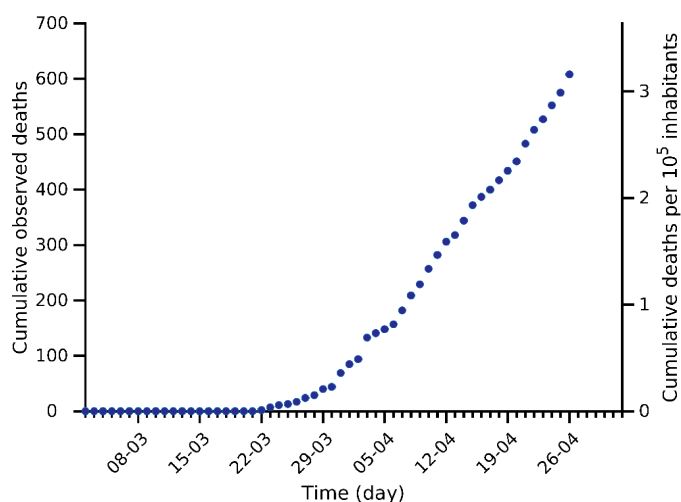
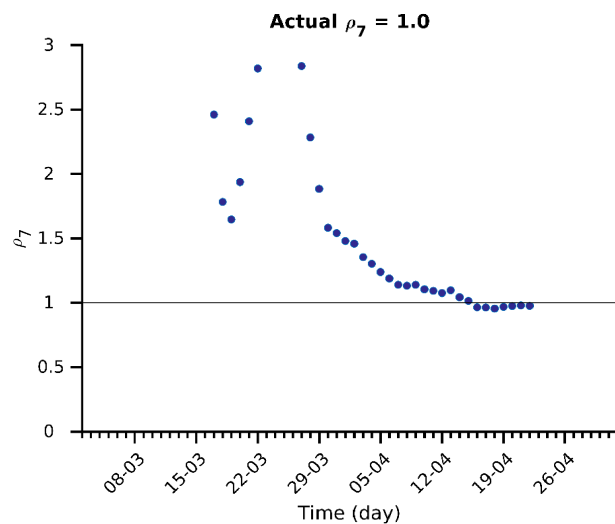
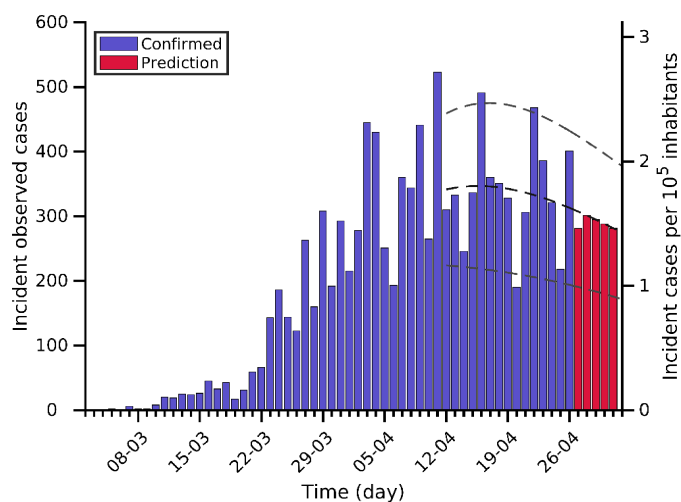
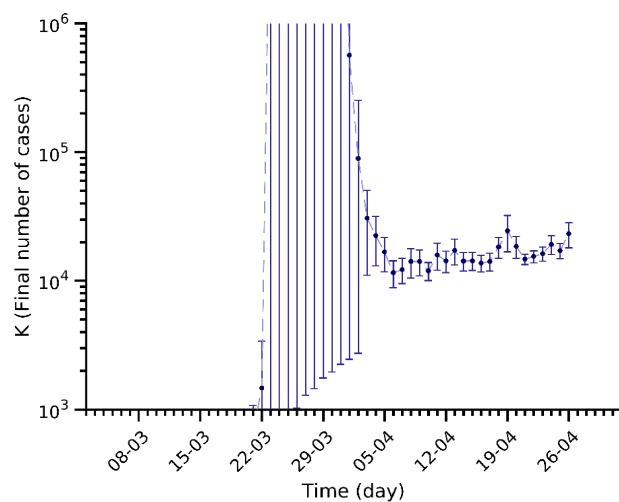
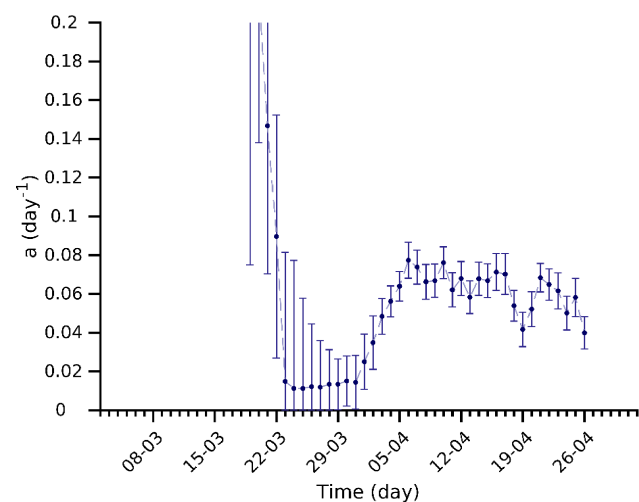
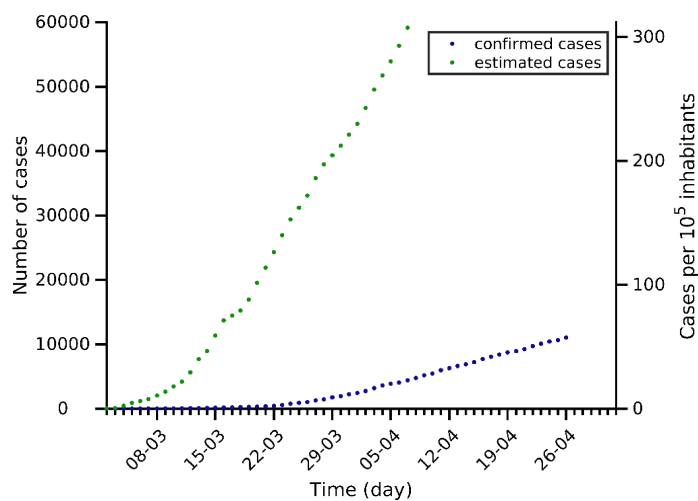
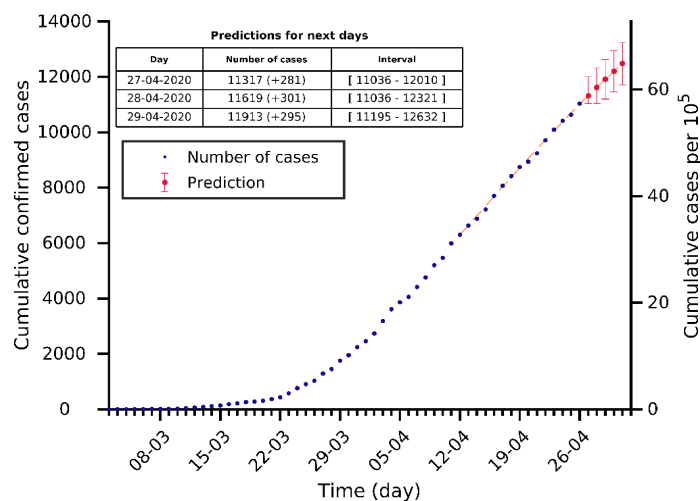
# Austria 26-04-2020. Population: 9.0M. Current cumulated incidence: 169/10<sup>5</sup>



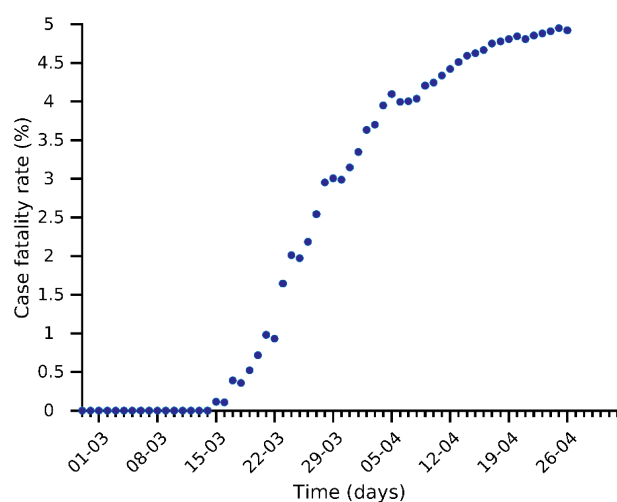
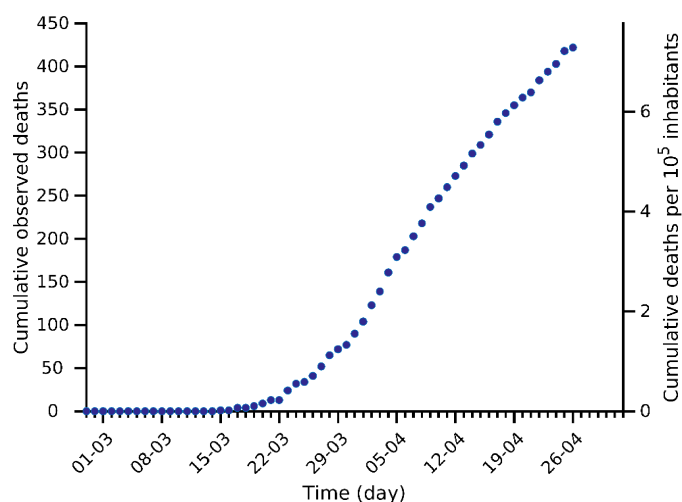
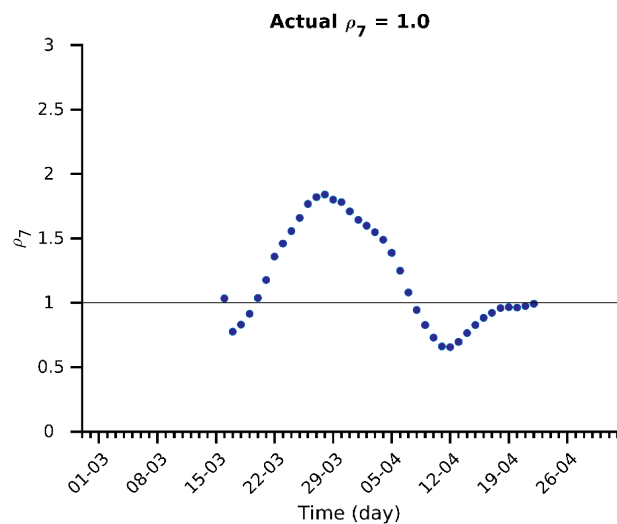
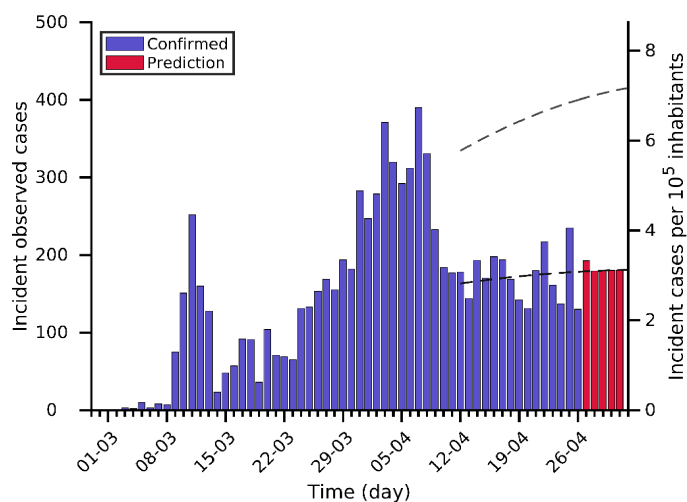
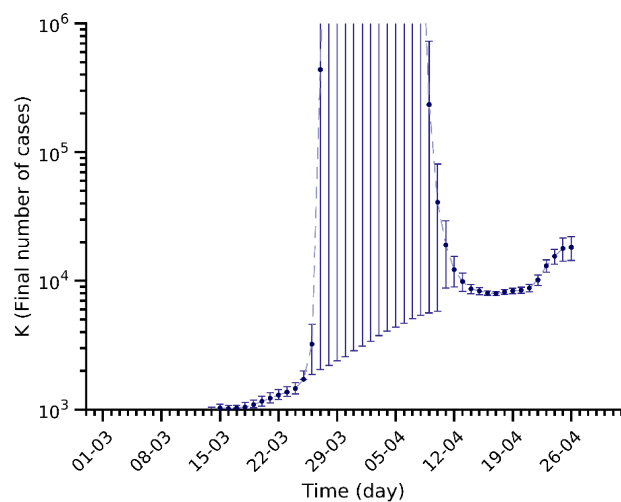
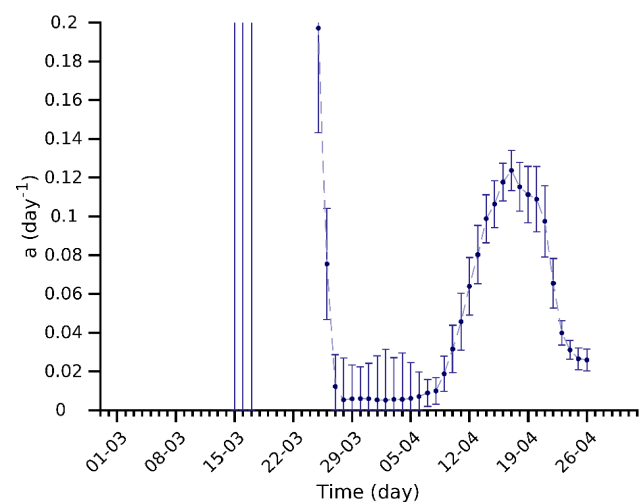
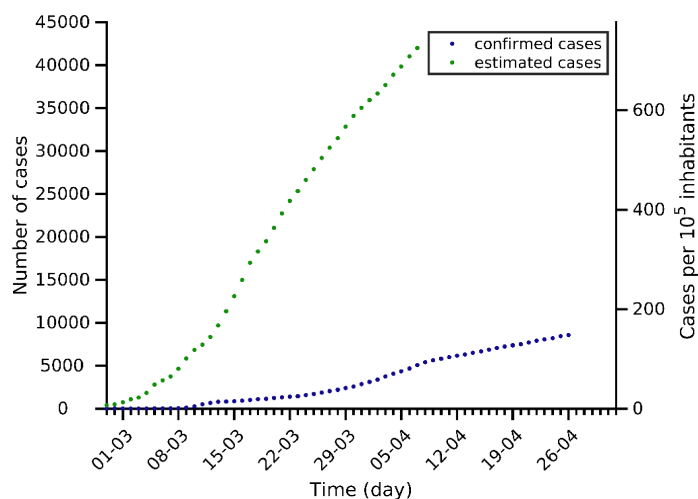
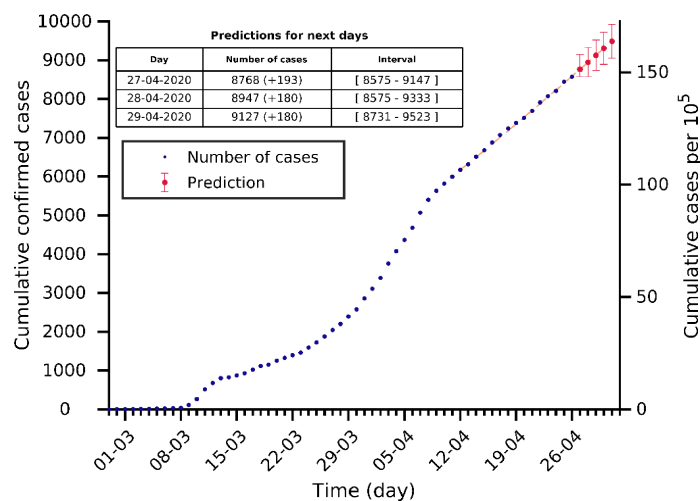
# Poland 26-04-2020. Population: 37.8M. Current cumulated incidence: 31/10<sup>5</sup>



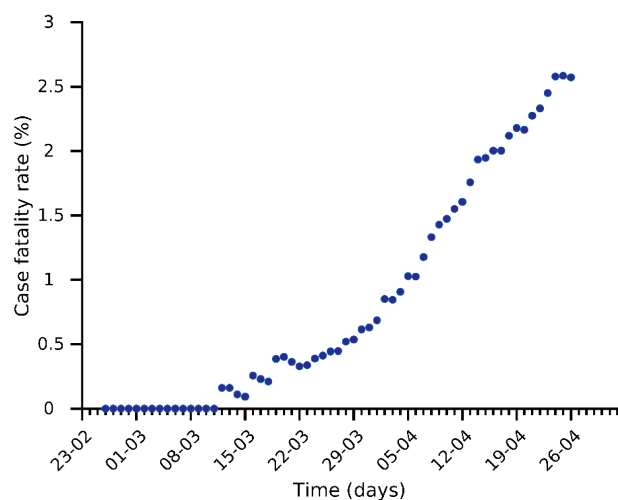
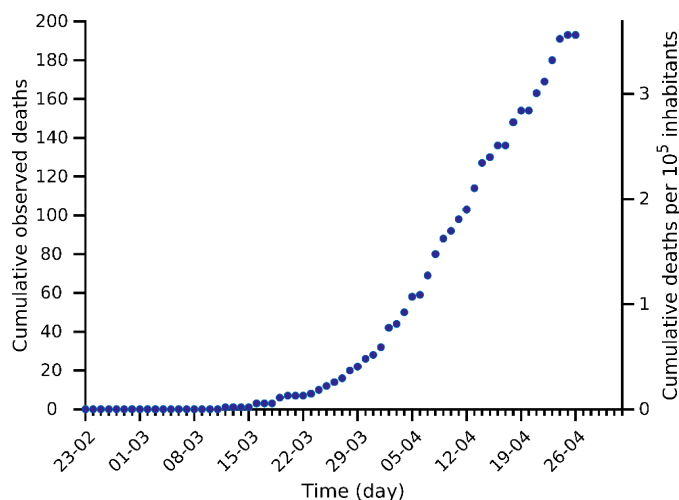
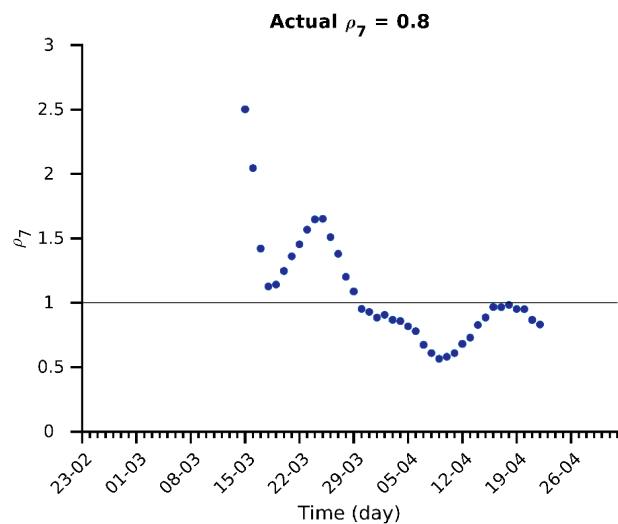
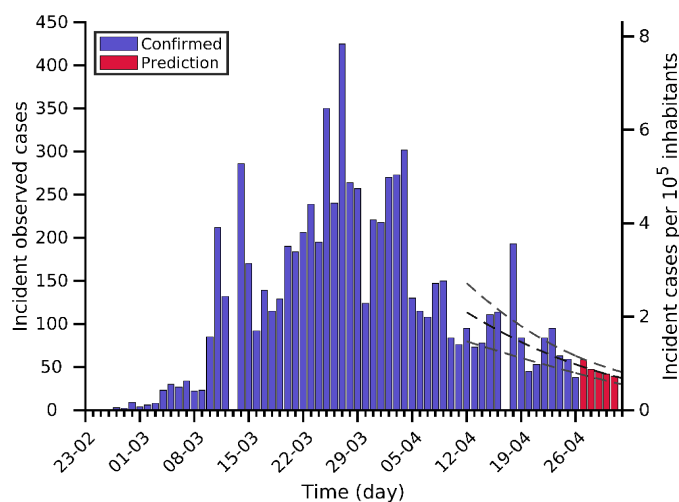
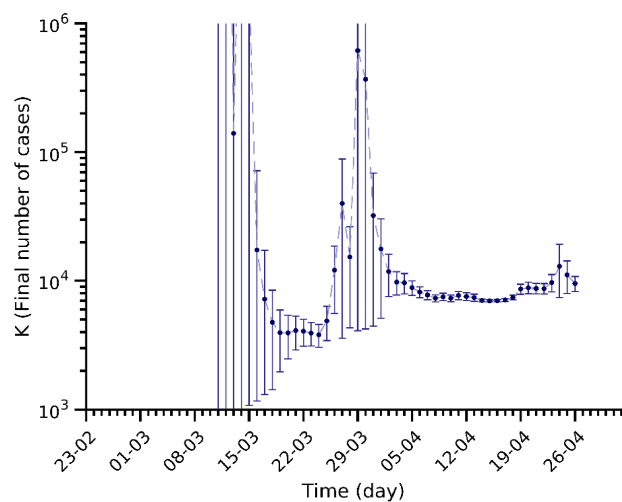
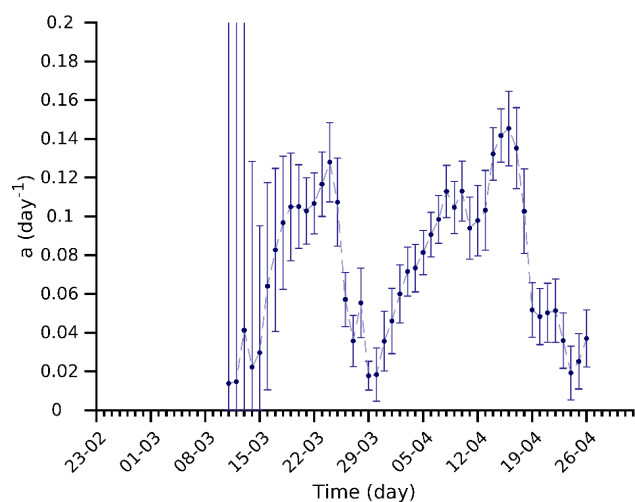
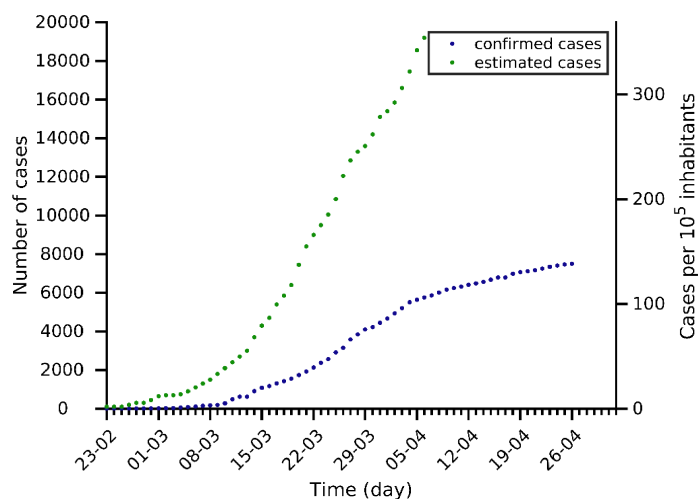
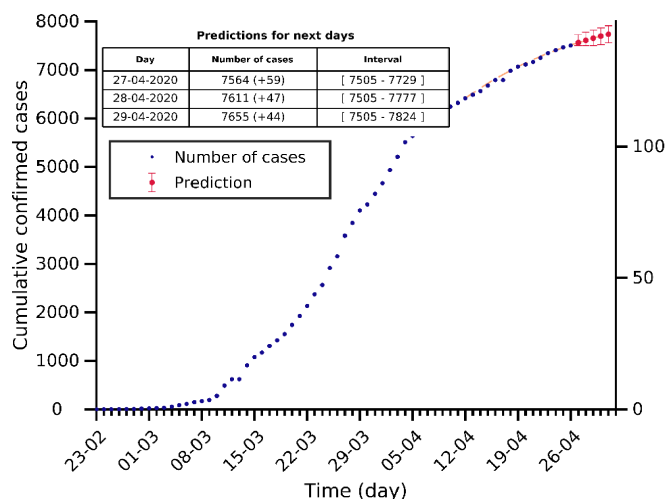
# Romania 26-04-2020. Population: 19.2M. Current cumulated incidence: 57/10<sup>5</sup>



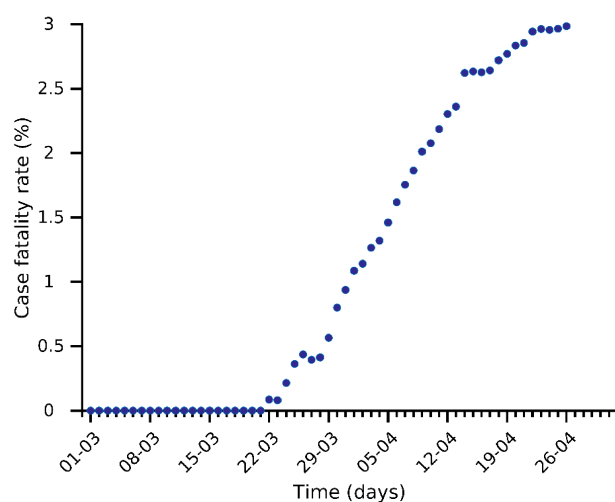
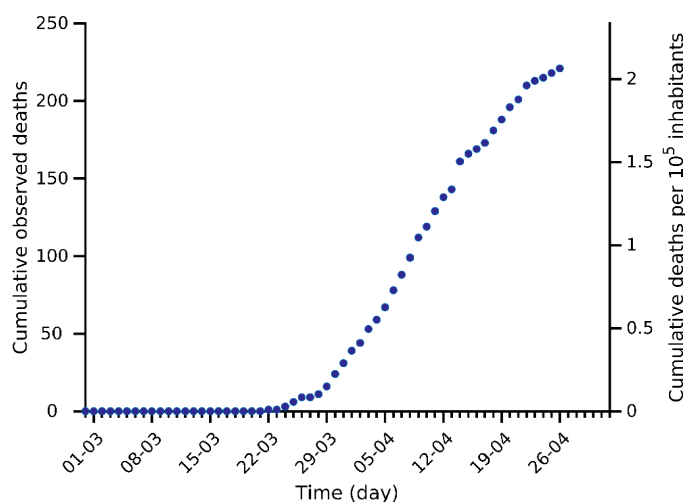
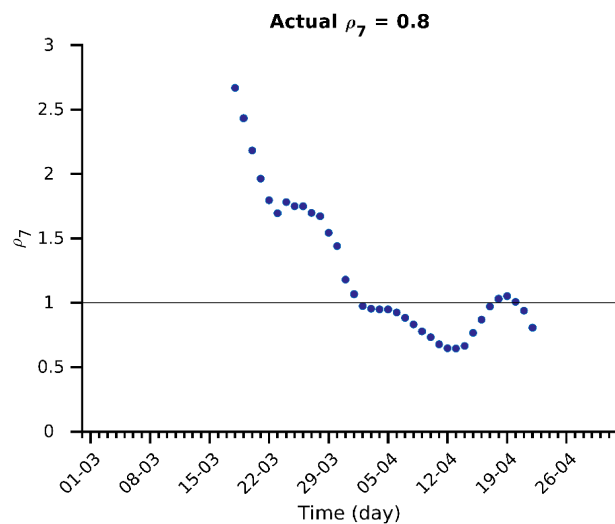
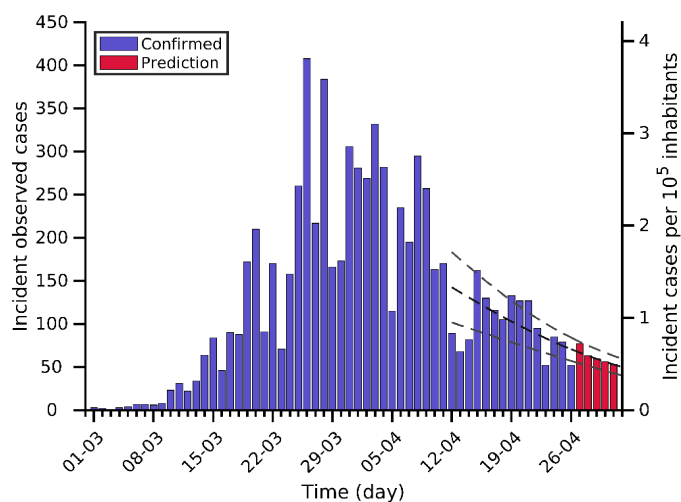
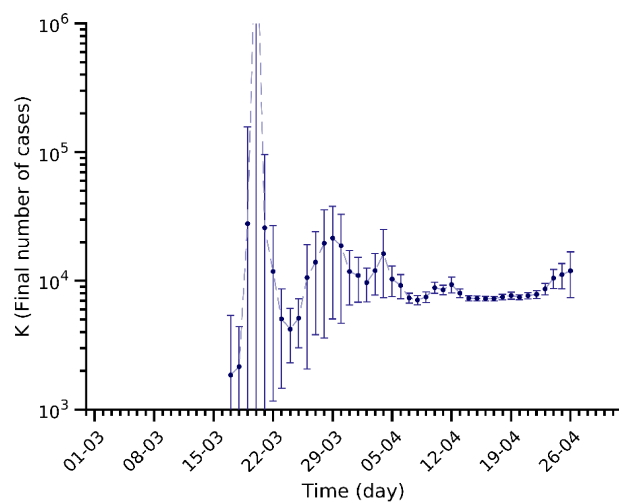
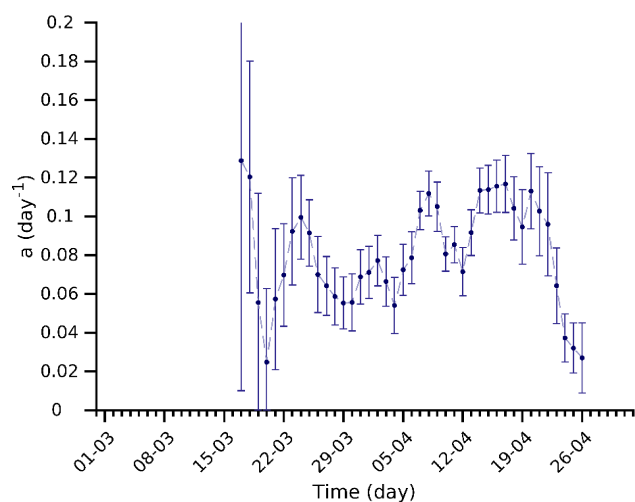
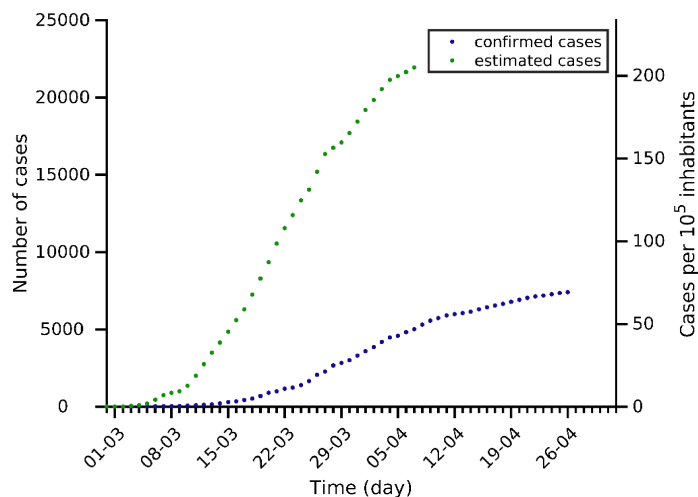
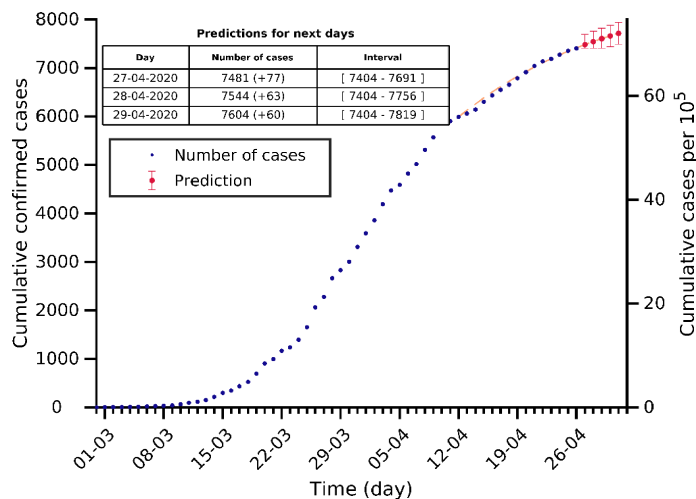
# Denmark 26-04-2020. Population: 5.8M. Current cumulated incidence: 148/10<sup>5</sup>



# Norway 26-04-2020. Population: 5.4M. Current cumulated incidence: 138/10<sup>5</sup>

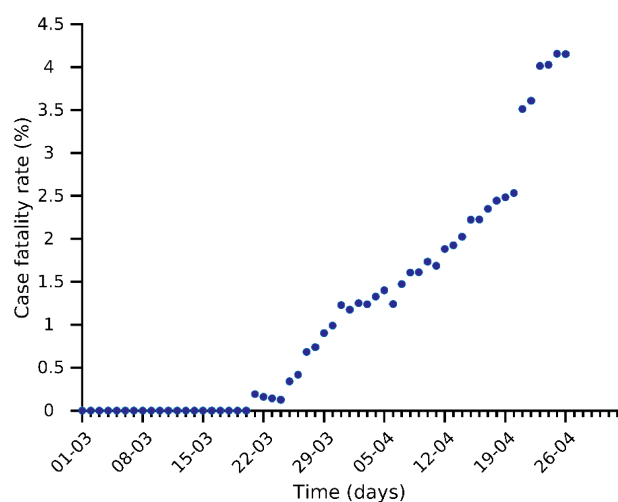
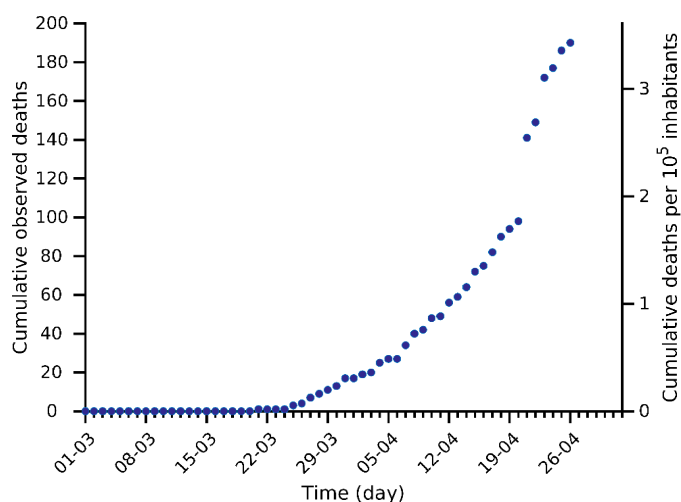
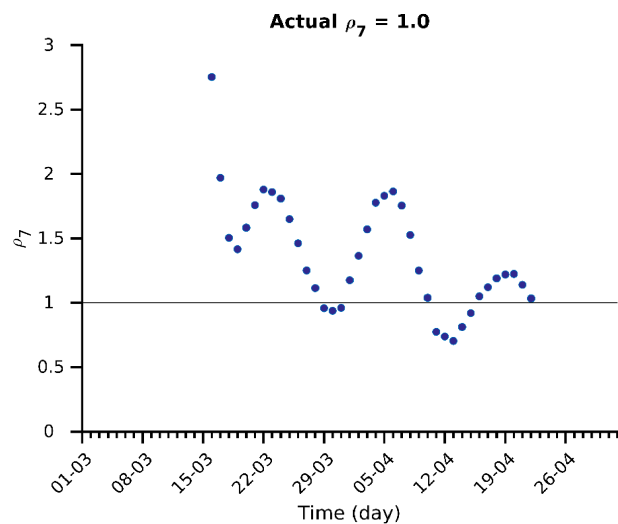
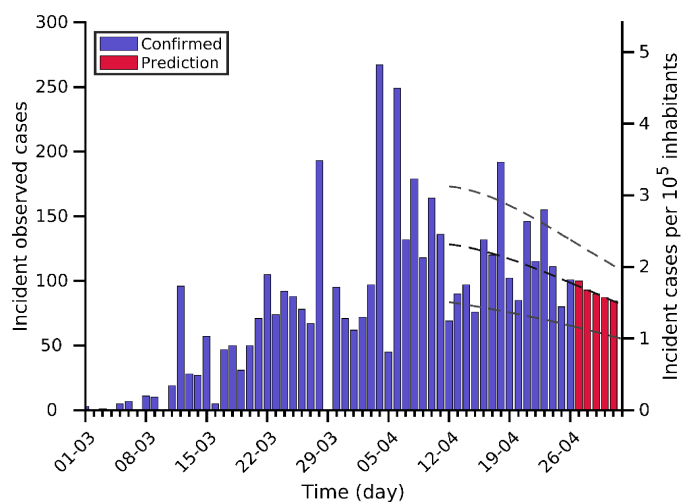
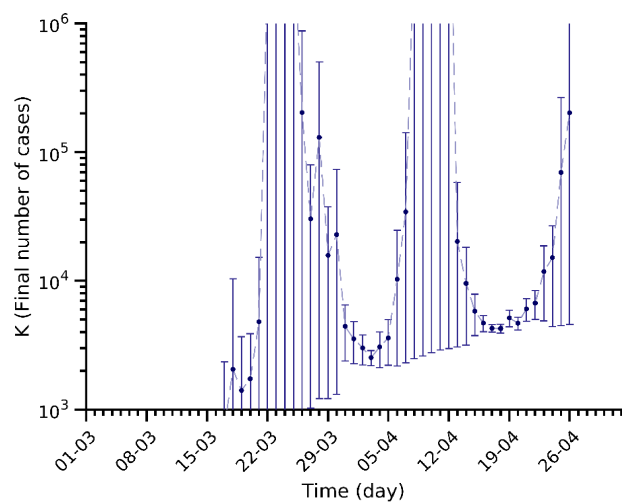
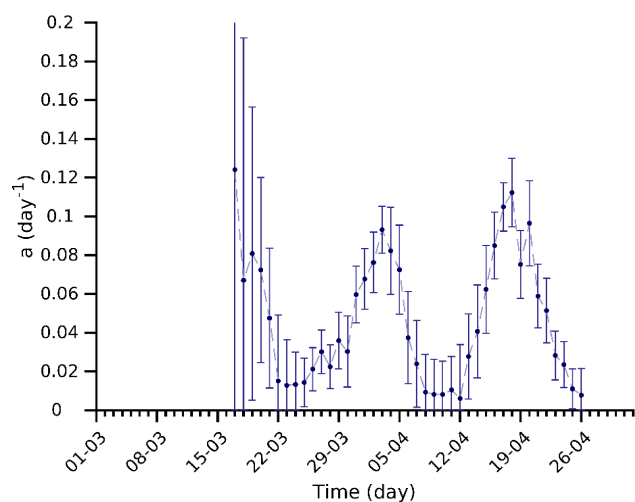
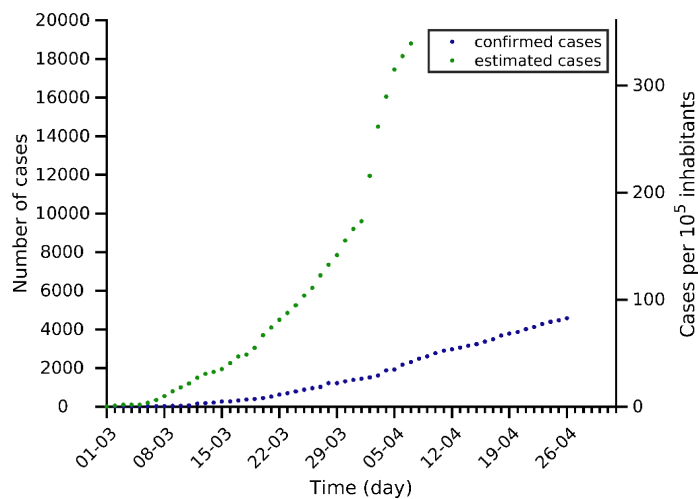
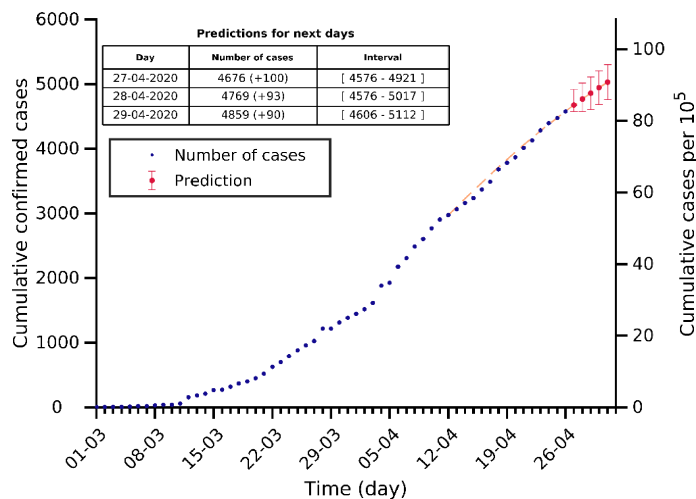


# Czech Rep 26-04-2020. Population: 10.7M. Current cumulated incidence: 69/10<sup>5</sup>

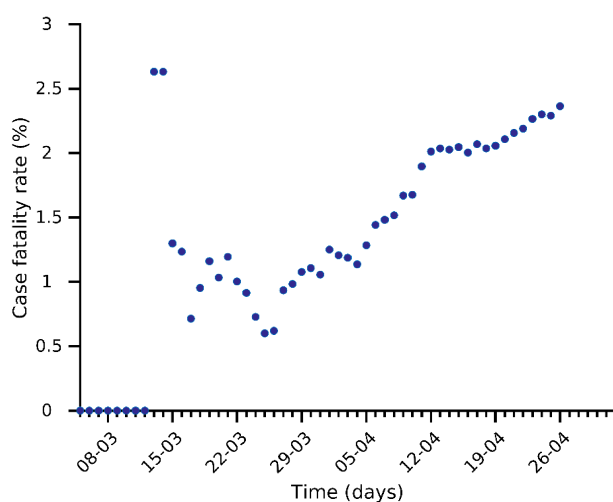
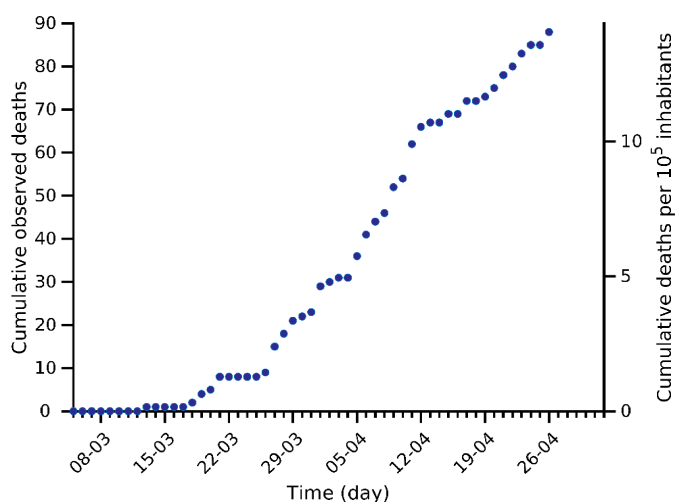
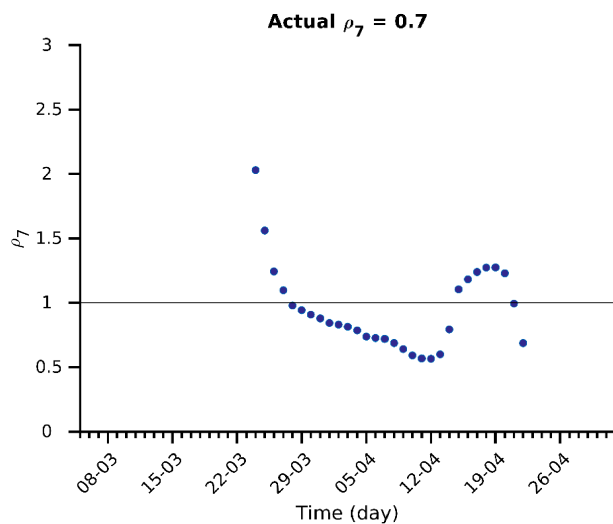
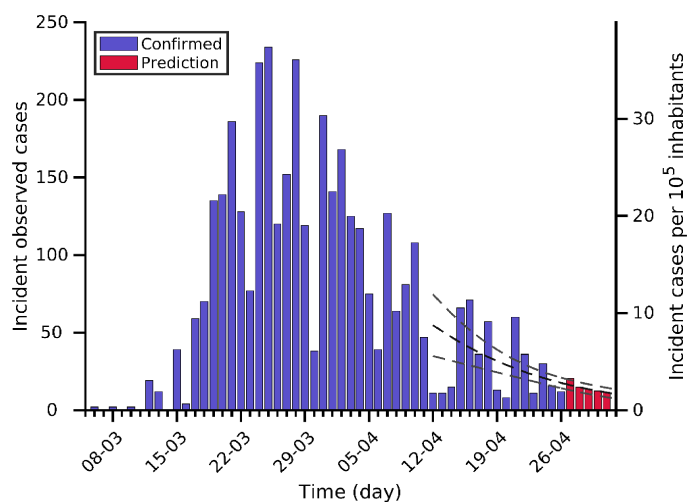
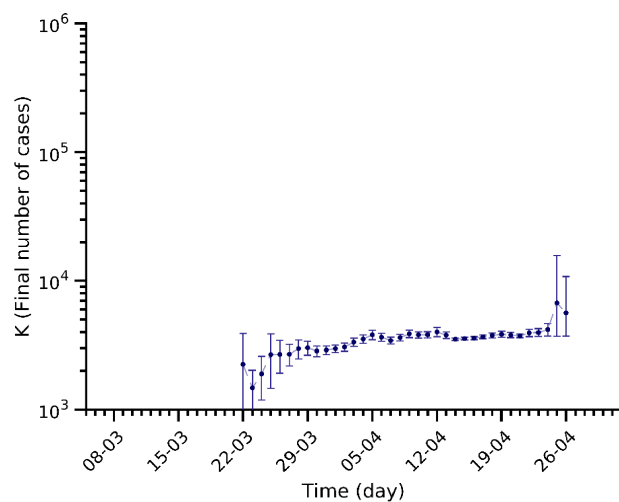
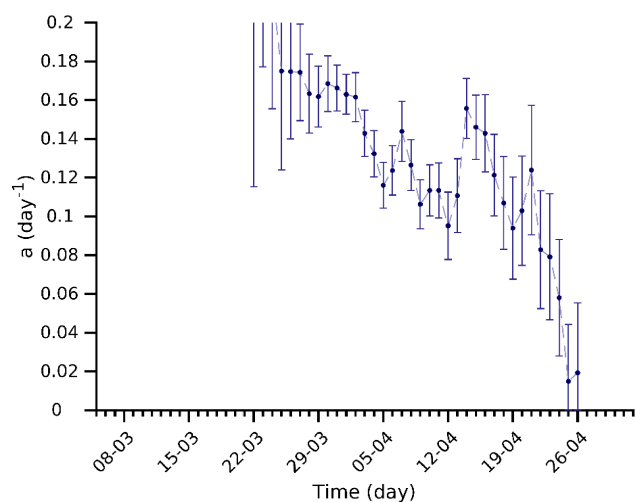
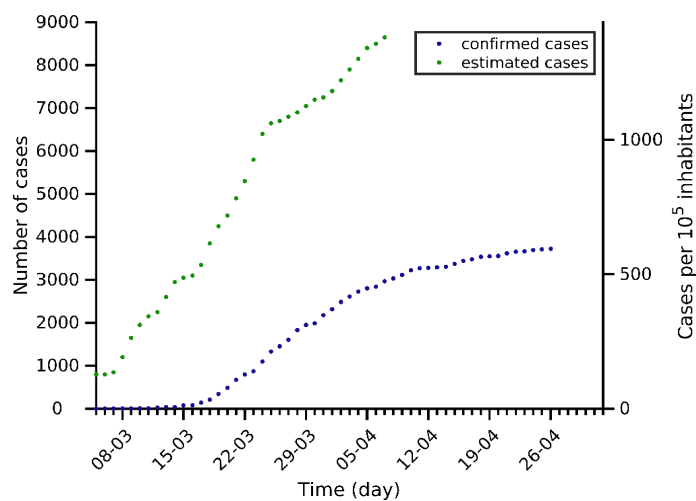
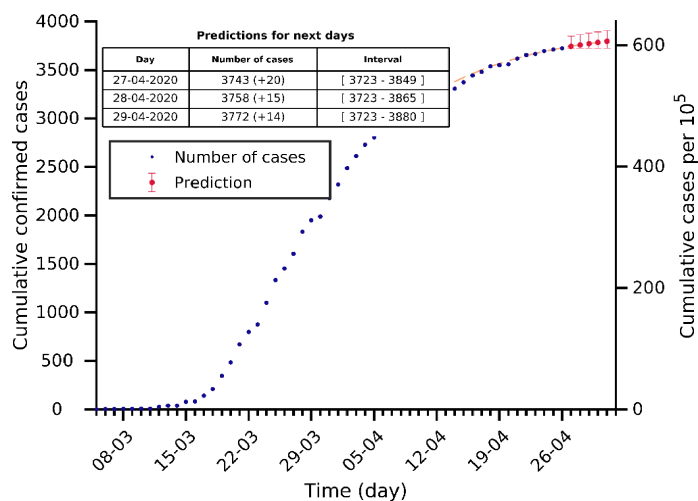




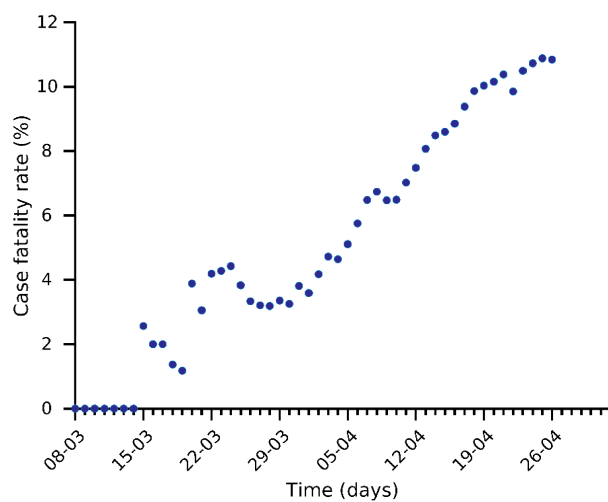
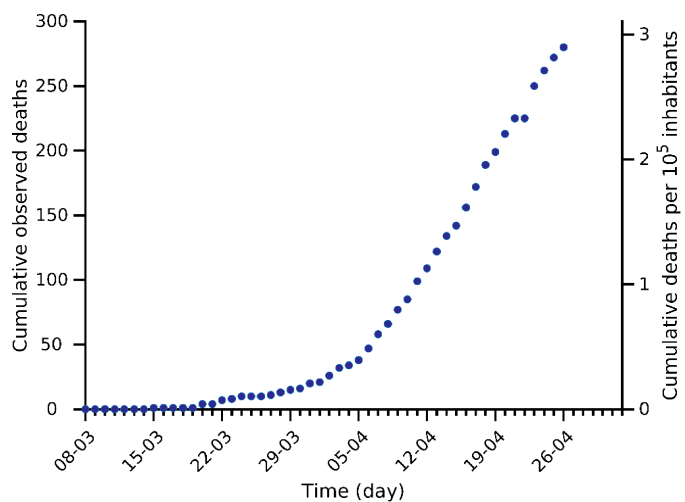
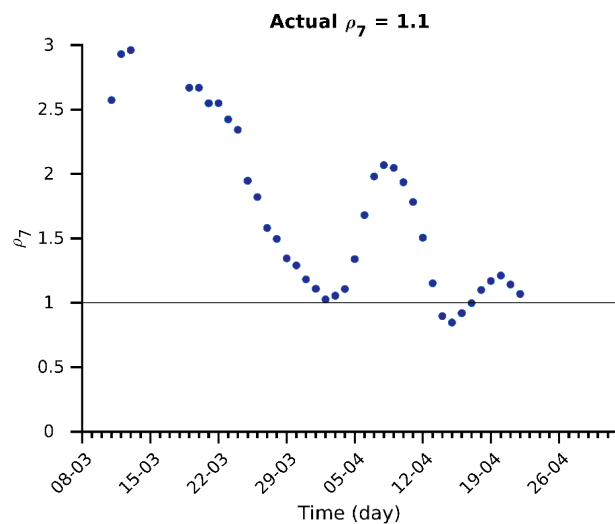
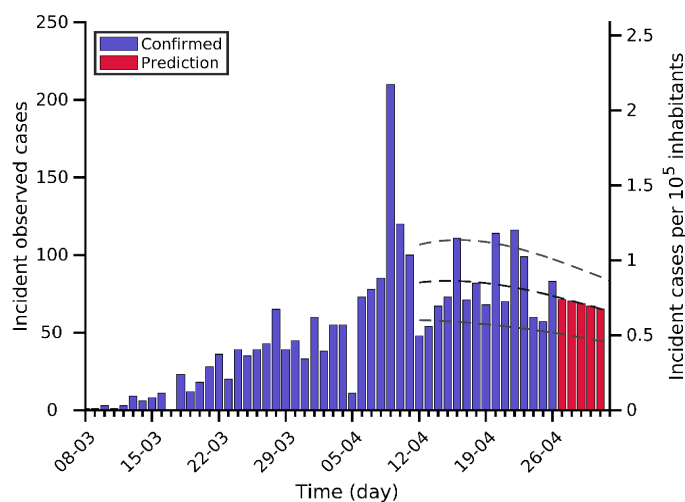
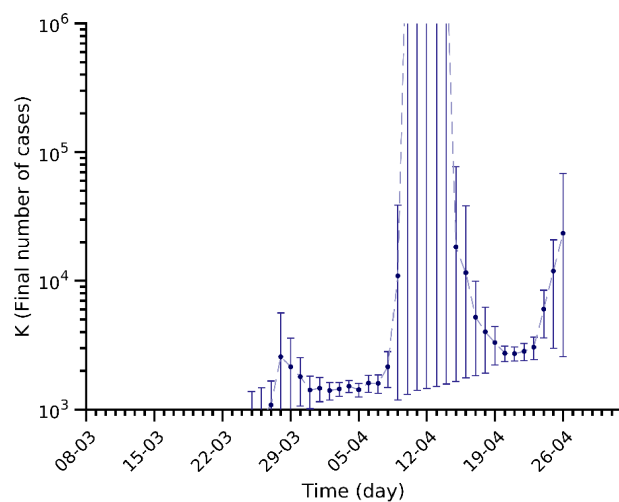
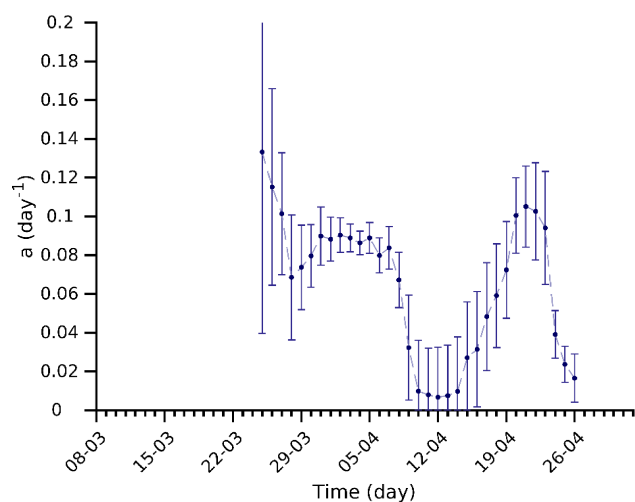
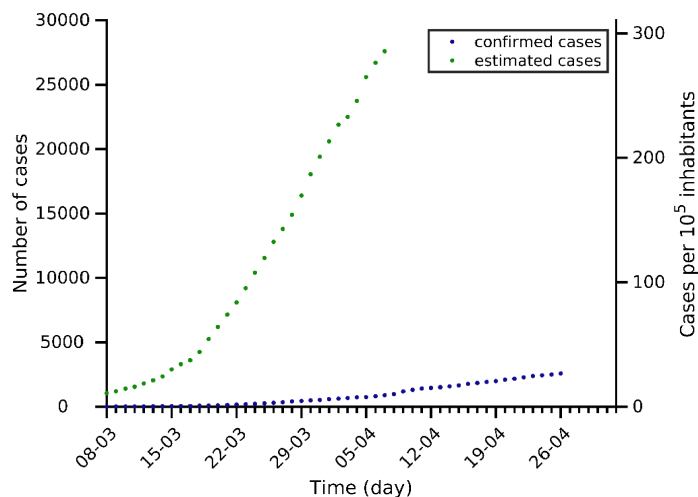
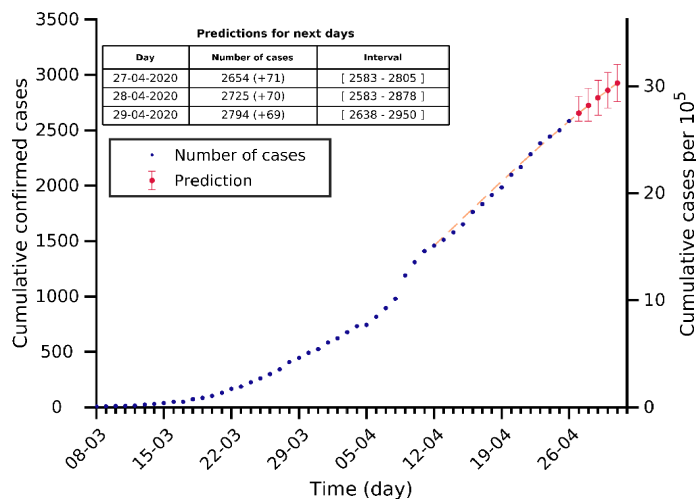
# Finland 26-04-2020. Population: 5.5M. Current cumulated incidence: 83/10<sup>5</sup>



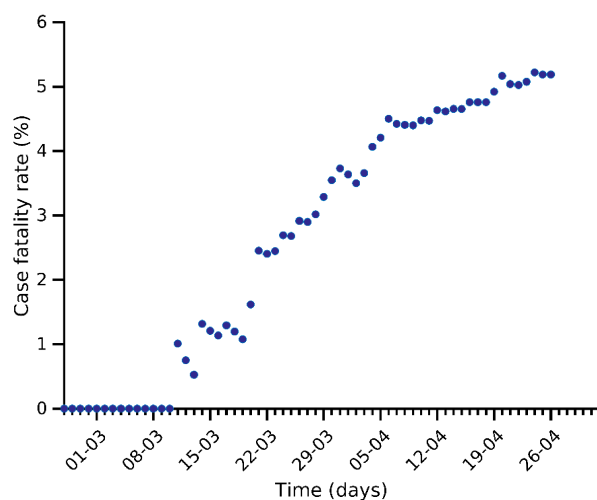
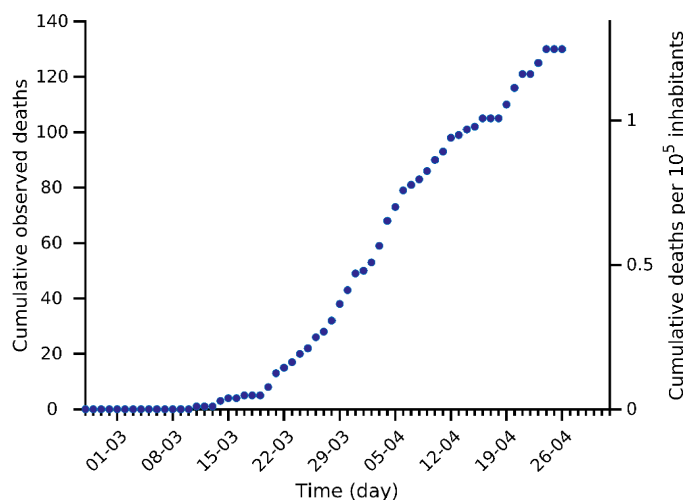
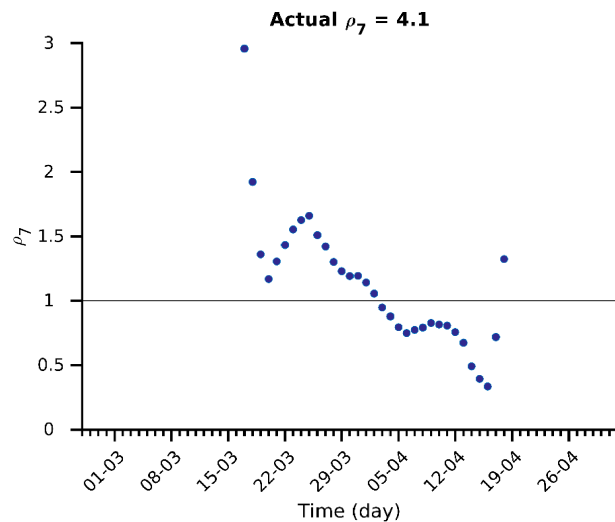
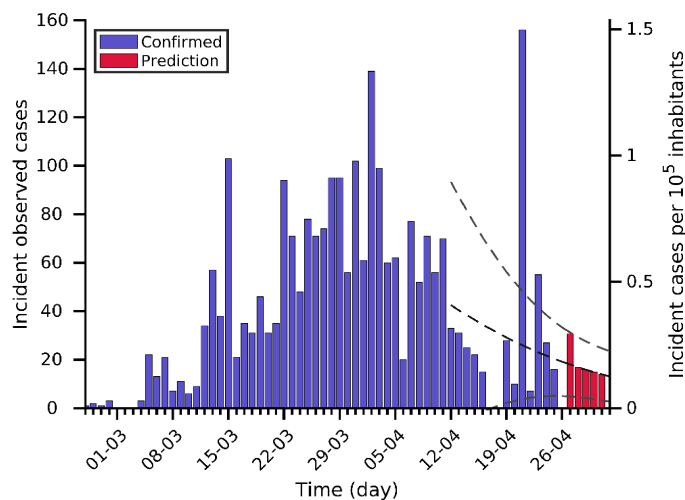
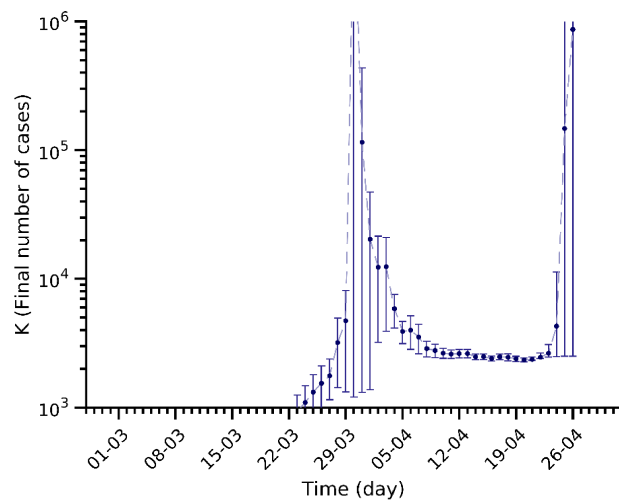
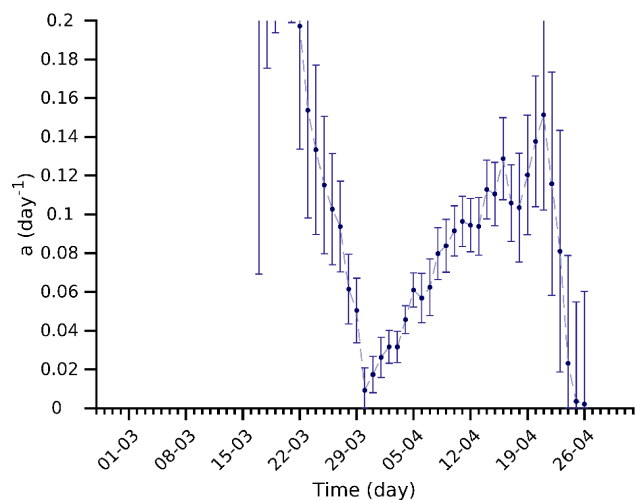
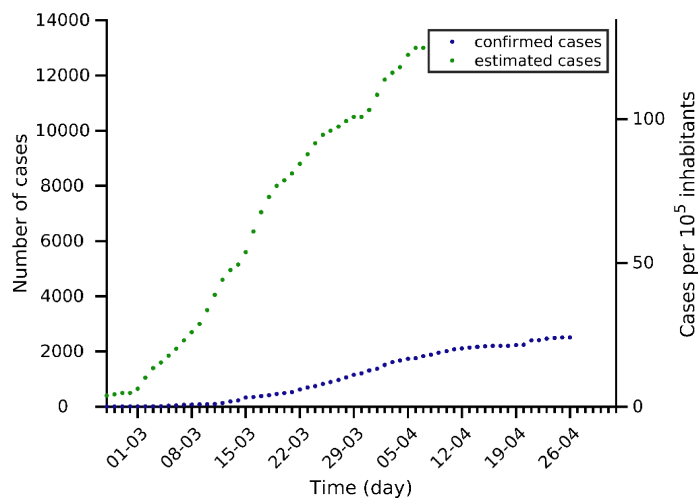
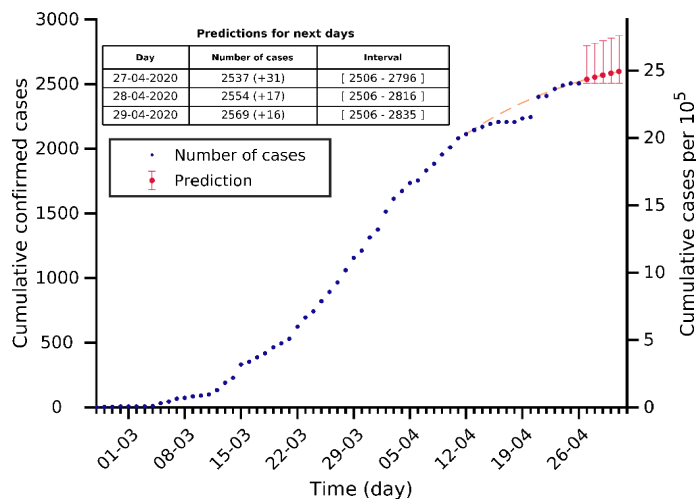
# Luxembourg 26-04-2020. Population: 0.6M. Current cumulated incidence: 595/10<sup>5</sup>



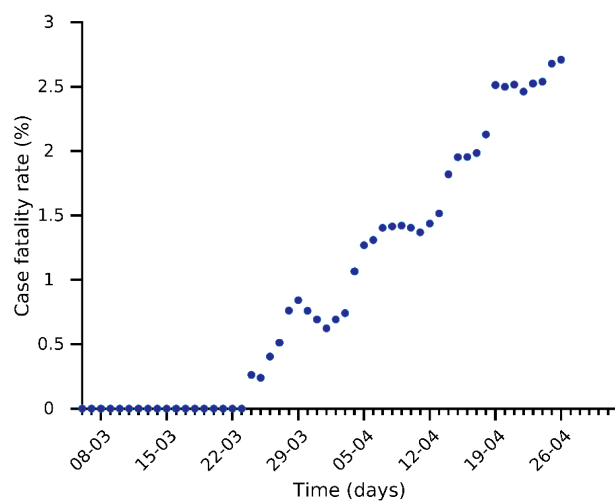
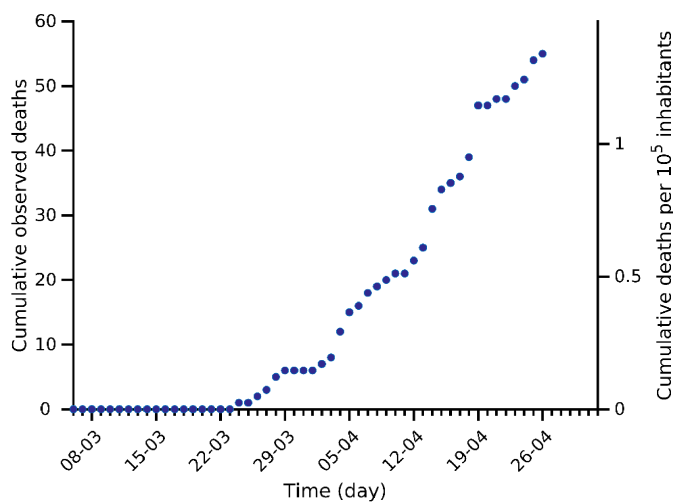
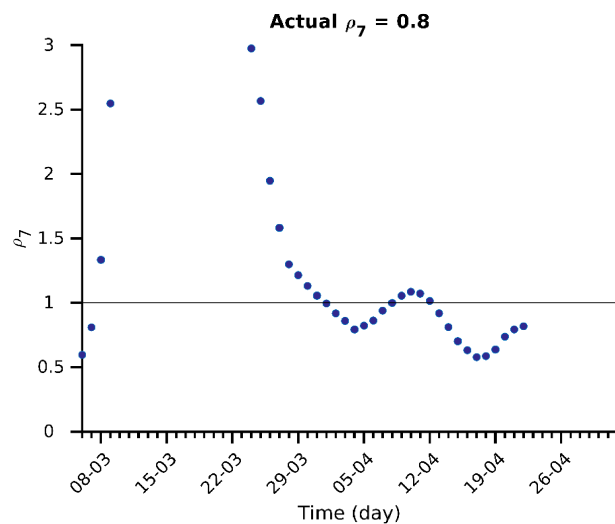
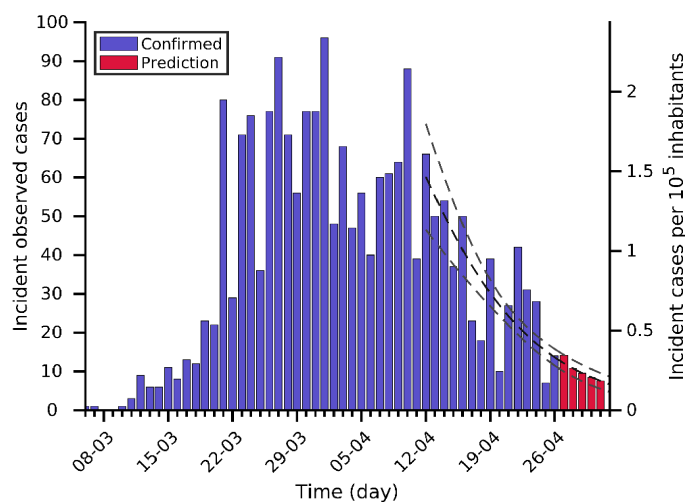
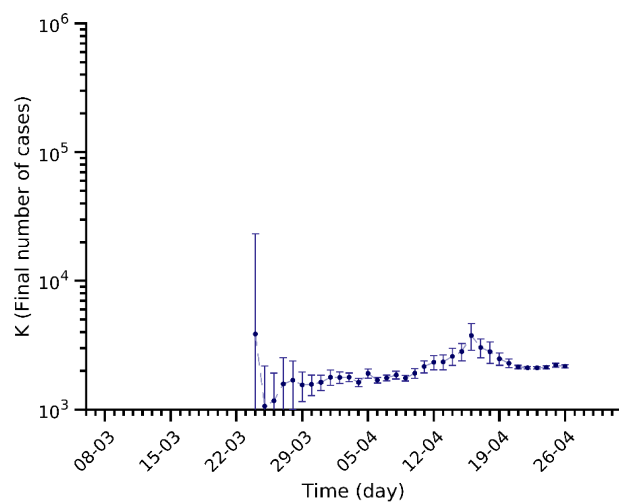
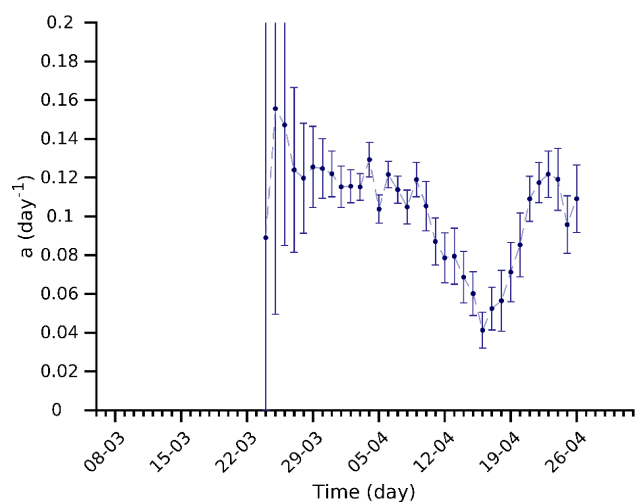
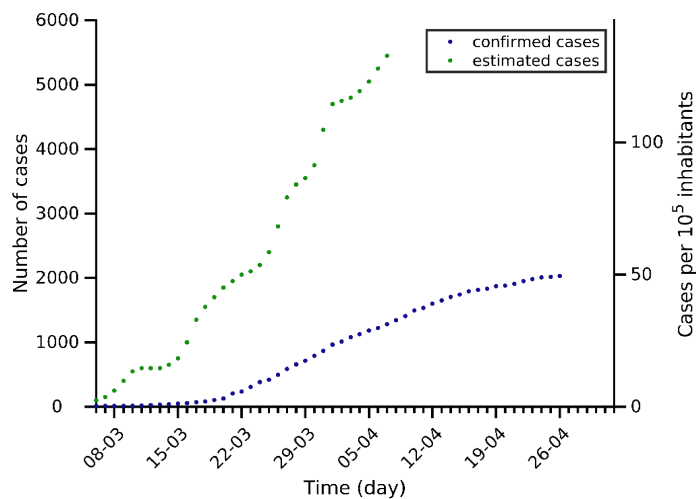
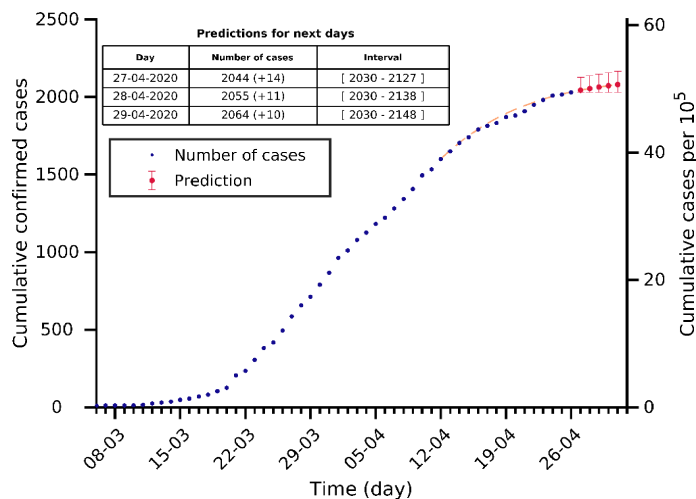
# Hungary 26-04-2020. Population: 9.7M. Current cumulated incidence: $27/10^5$



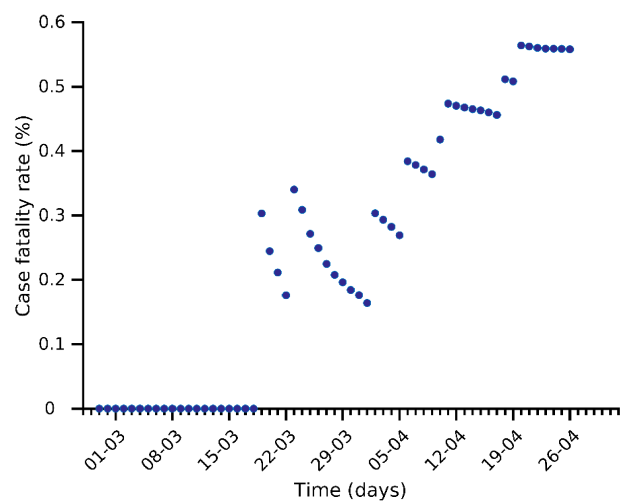
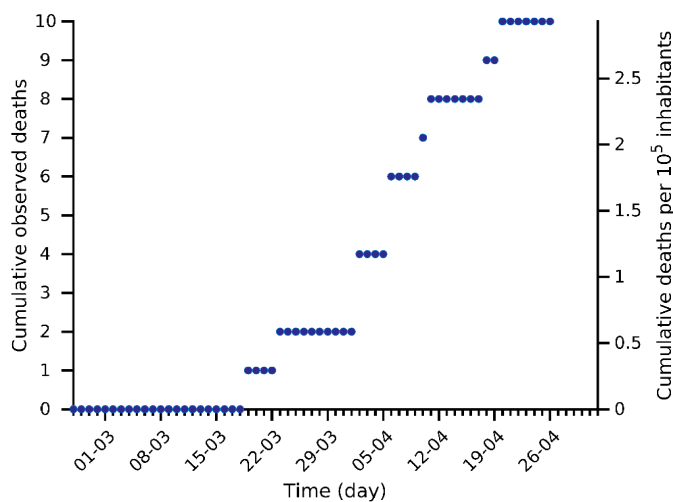
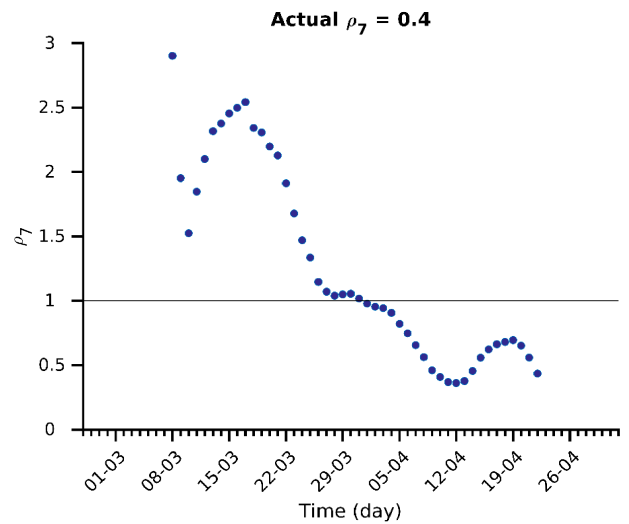
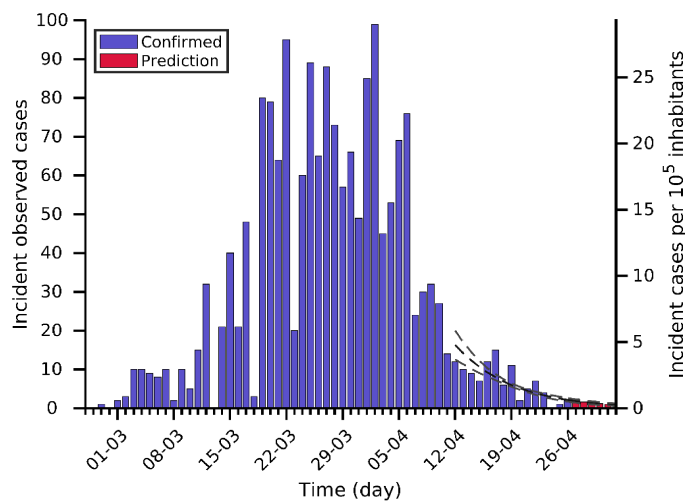
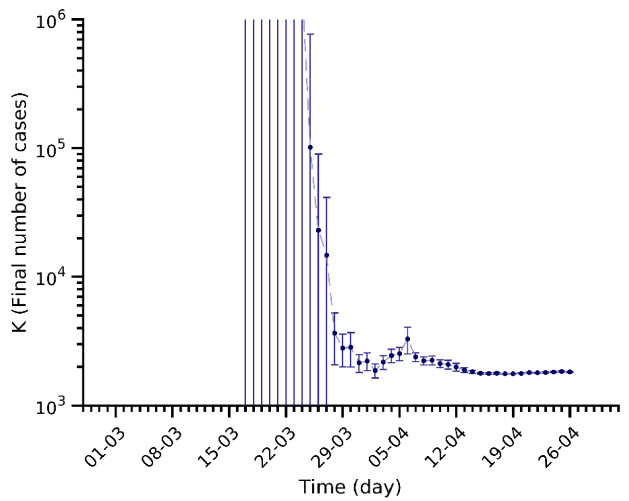
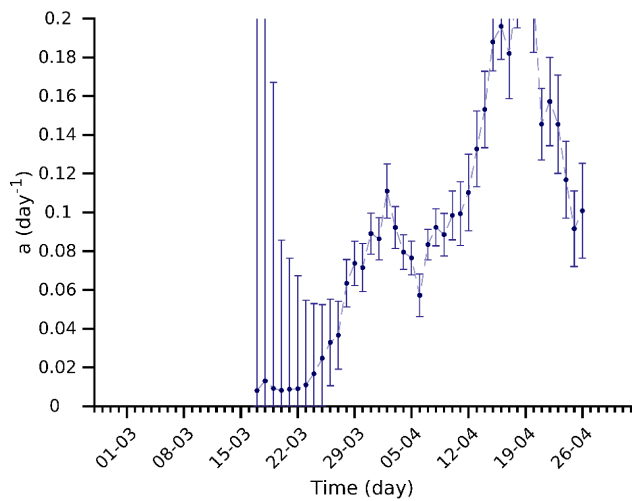
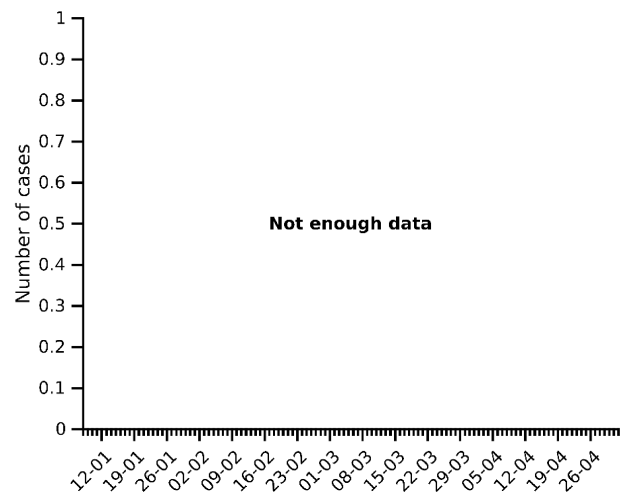
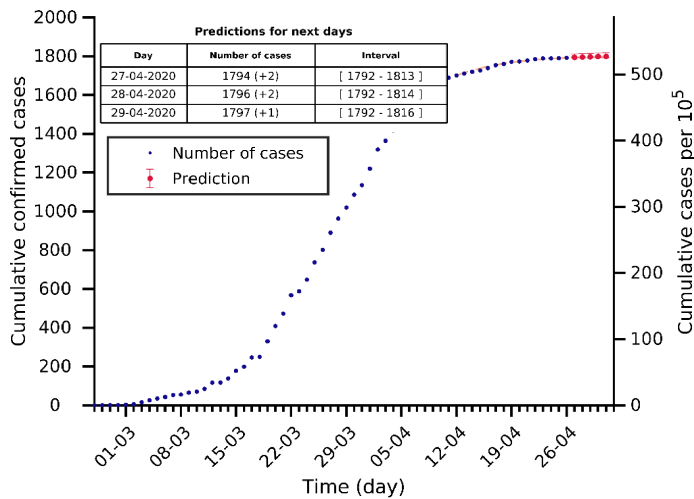
# Greece 26-04-2020. Population: 10.4M. Current cumulated incidence: 24/10<sup>5</sup>



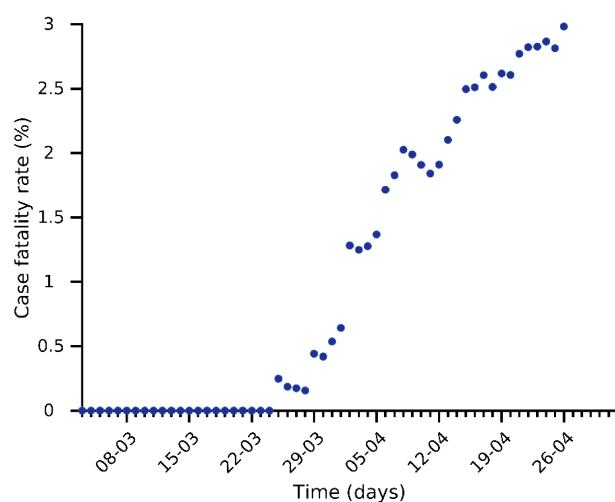
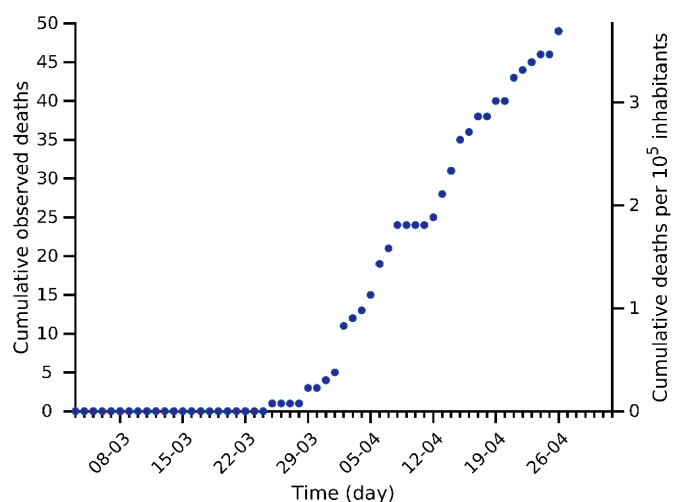
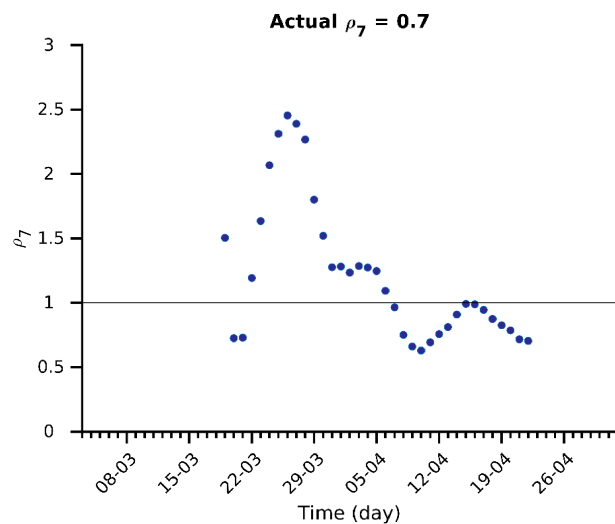
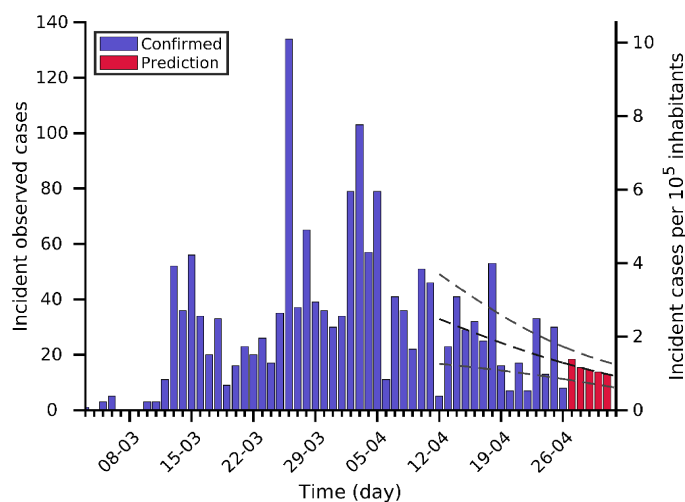
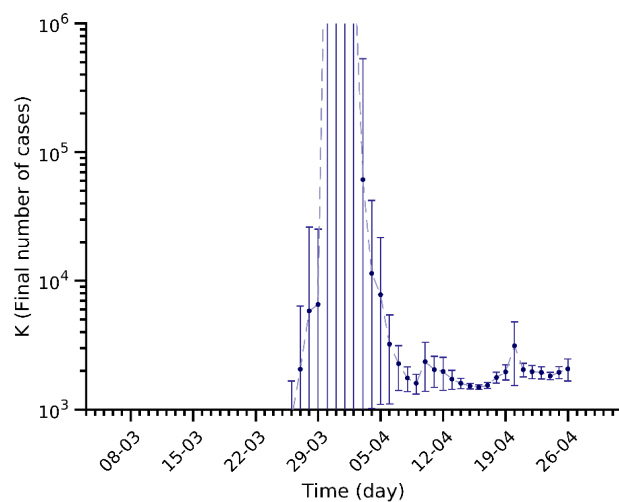
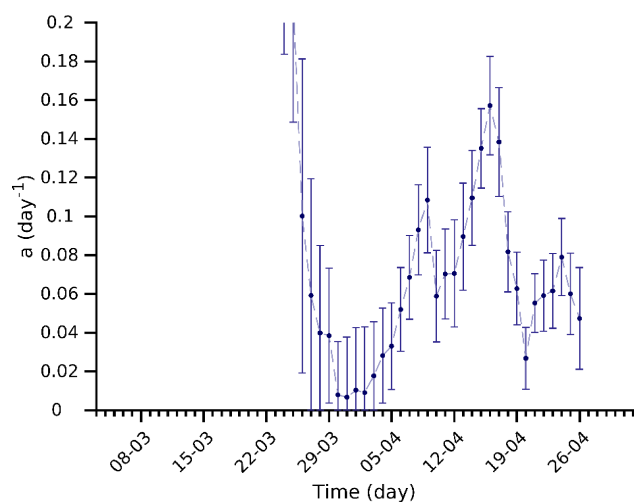
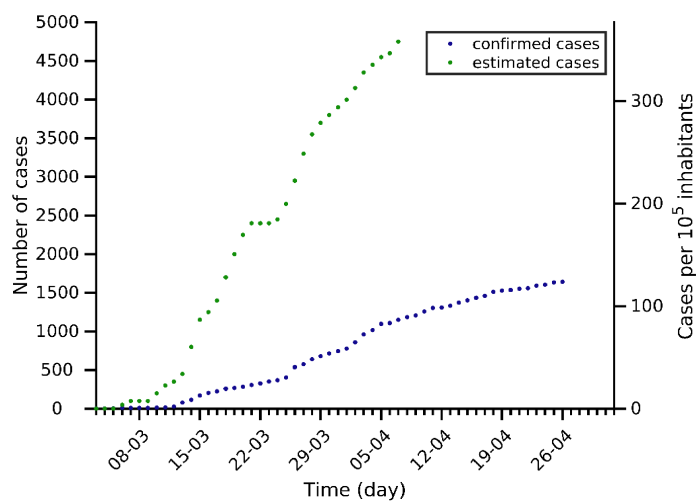
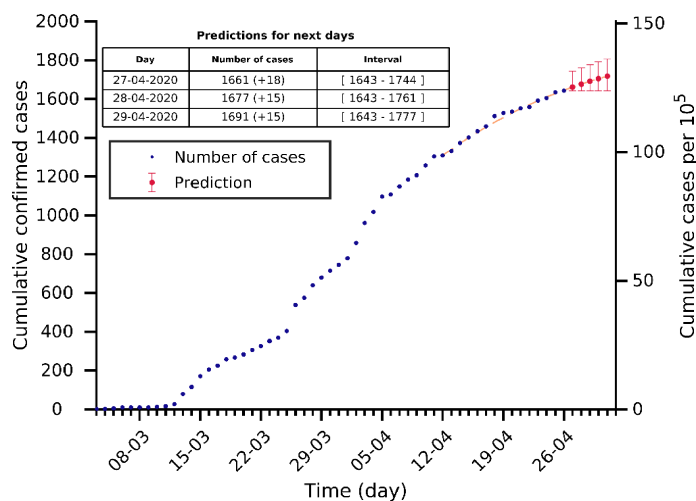
# Croatia 26-04-2020. Population: 4.1M. Current cumulated incidence: 49/10<sup>5</sup>



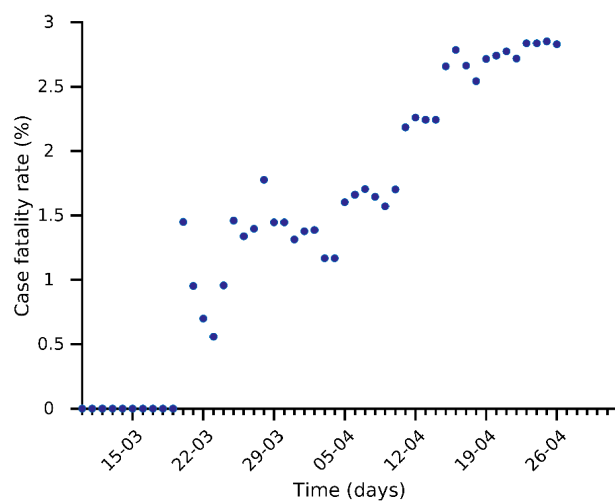
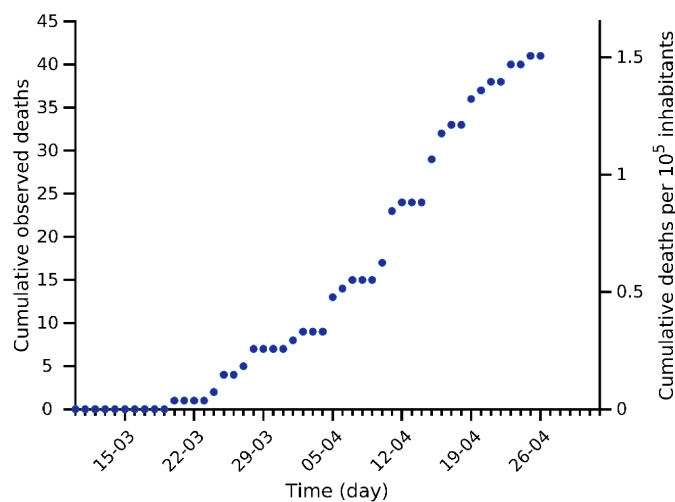
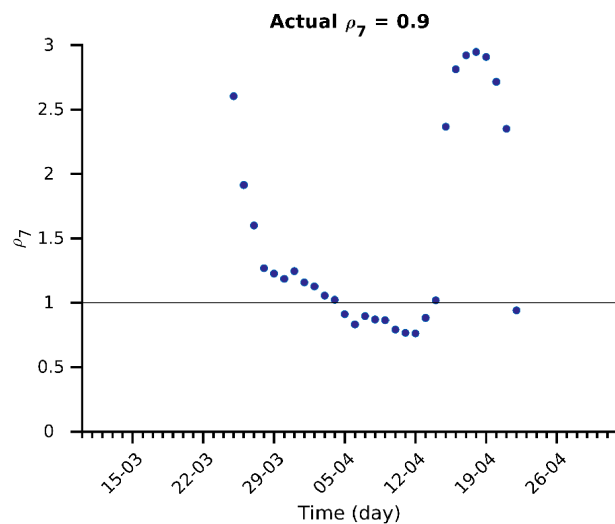
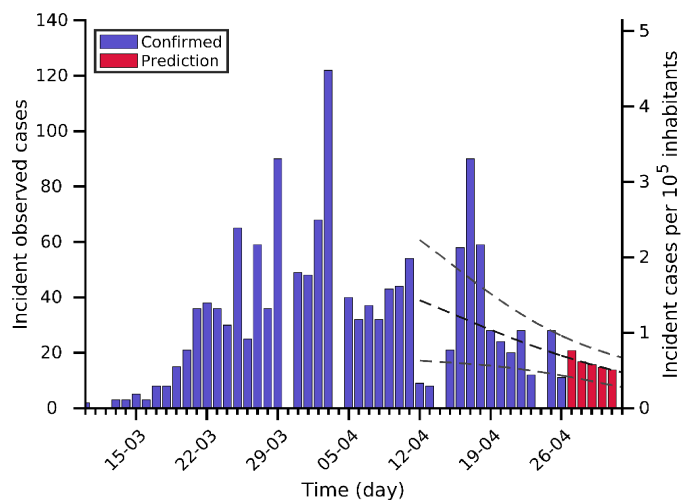
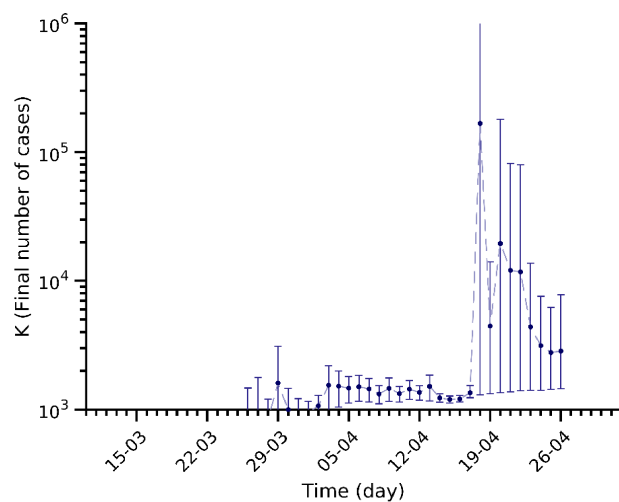
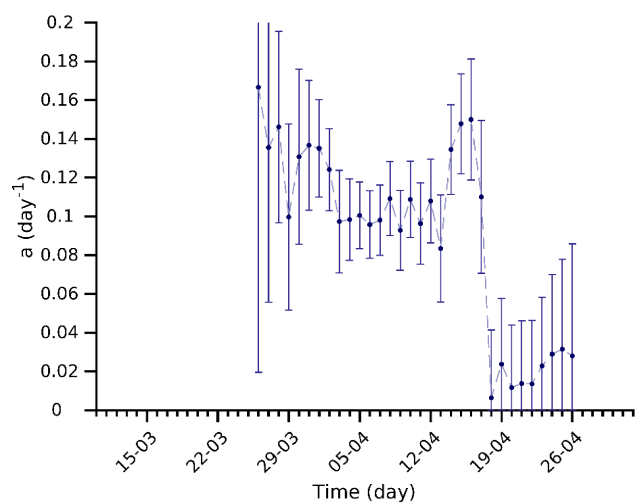
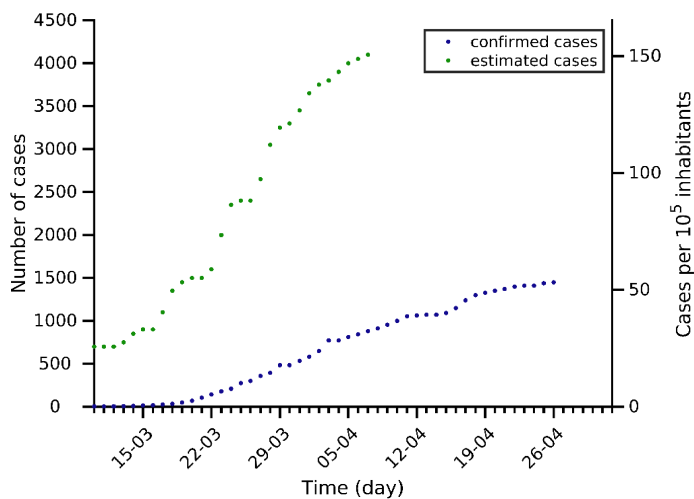
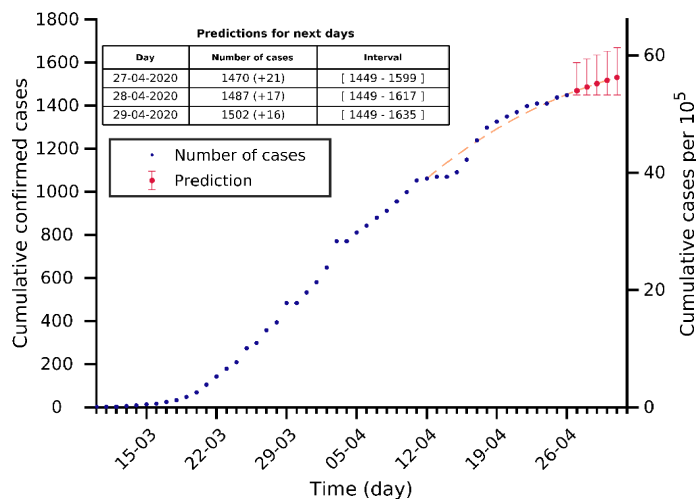
# Iceland 26-04-2020. Population: 0.3M. Current cumulated incidence: 525/10<sup>5</sup>



# Estonia 26-04-2020. Population: 1.3M. Current cumulated incidence: 124/10<sup>5</sup>

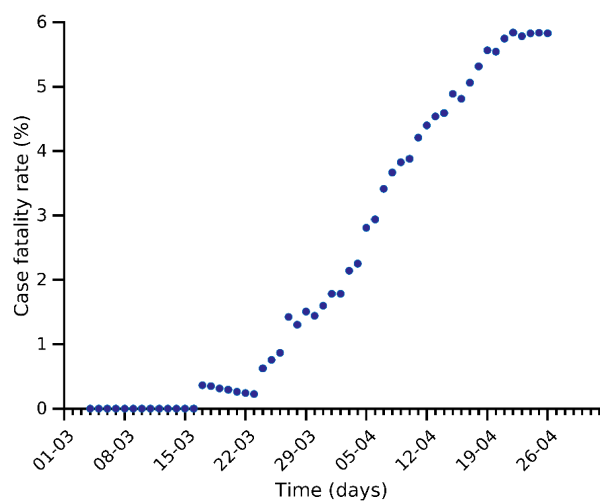
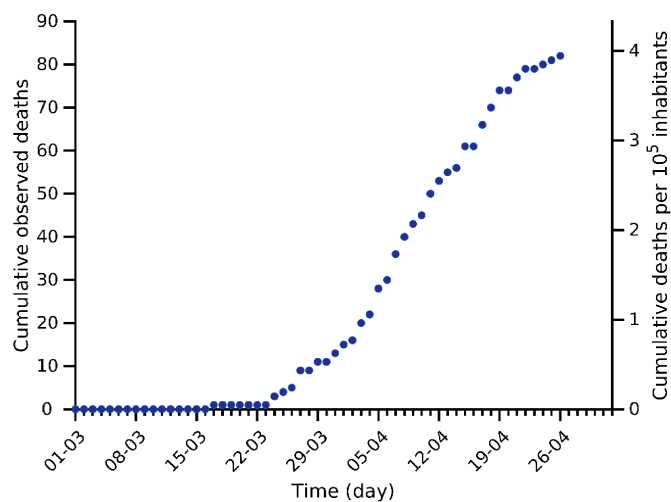
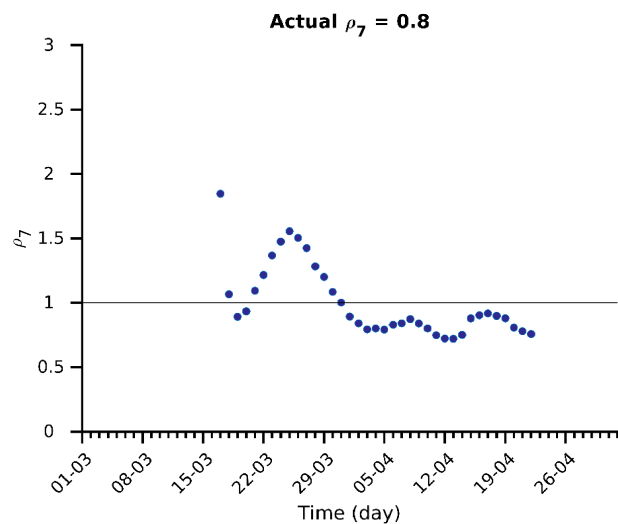
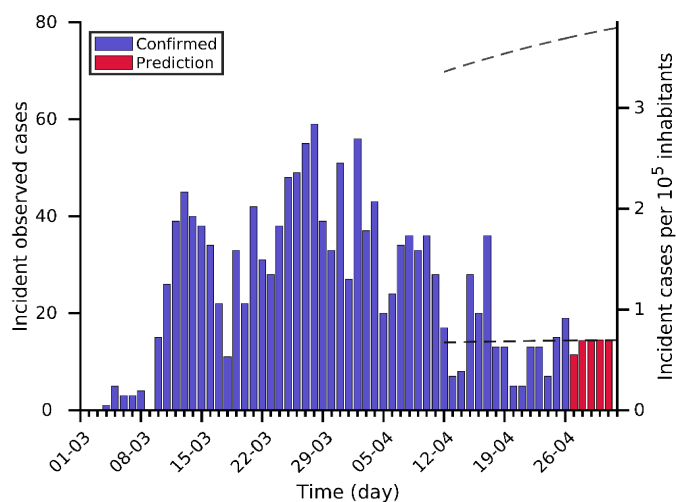
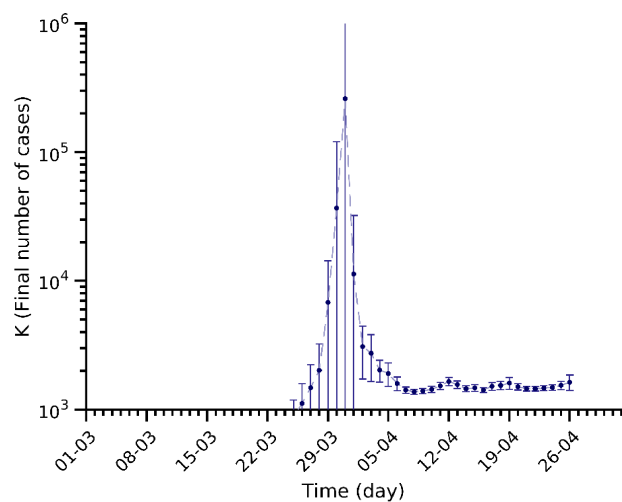
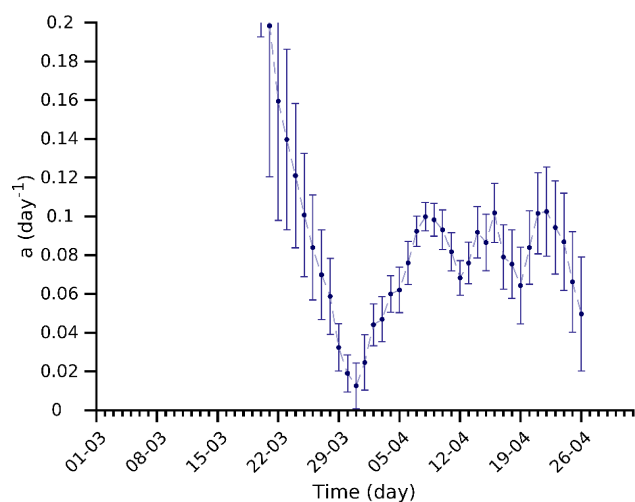
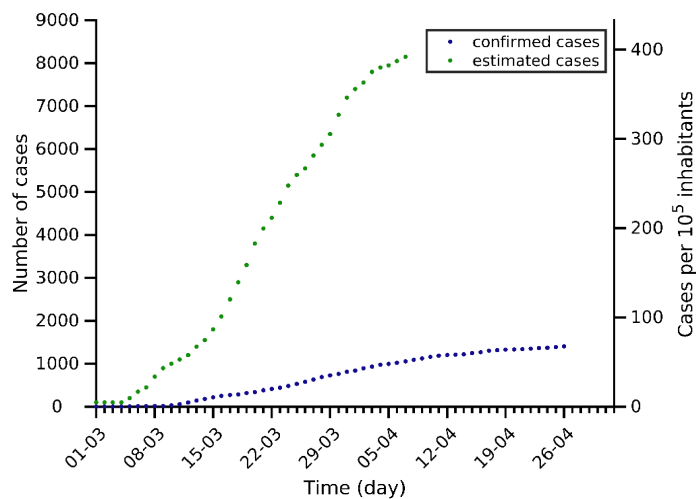
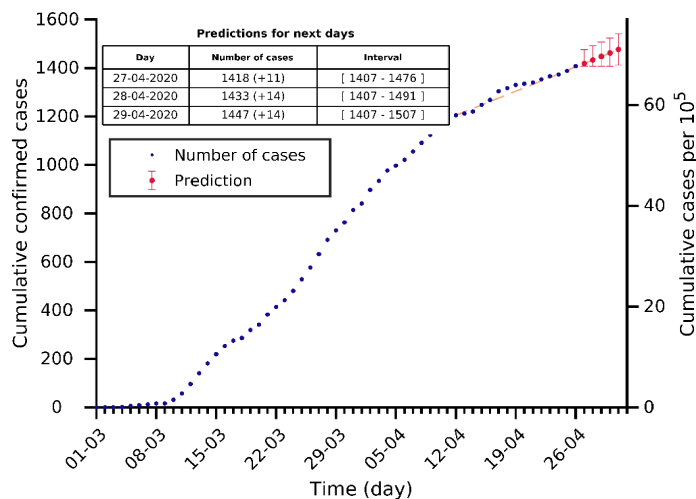


# Lithuania 26-04-2020. Population: 2.7M. Current cumulated incidence: 53/10<sup>5</sup>

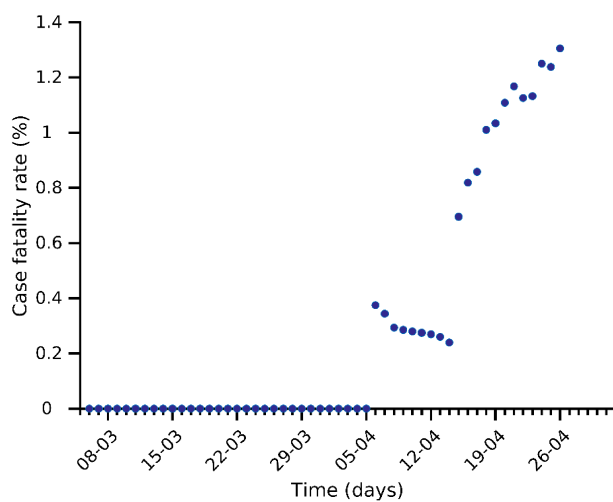
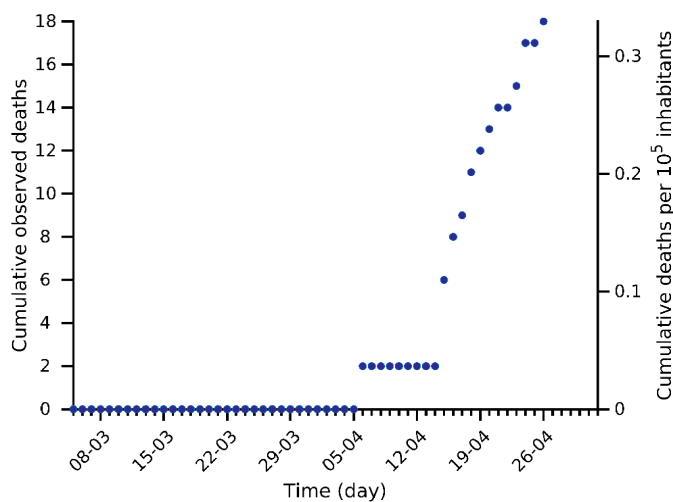
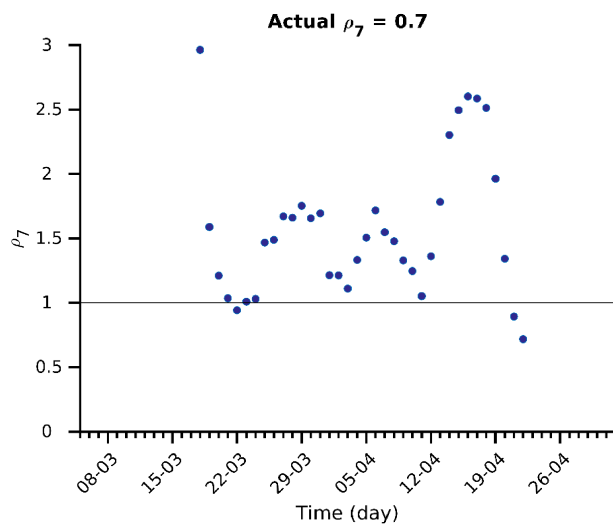
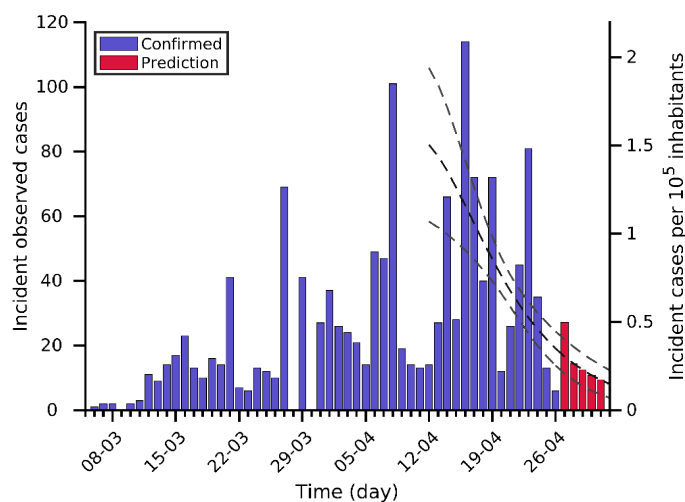
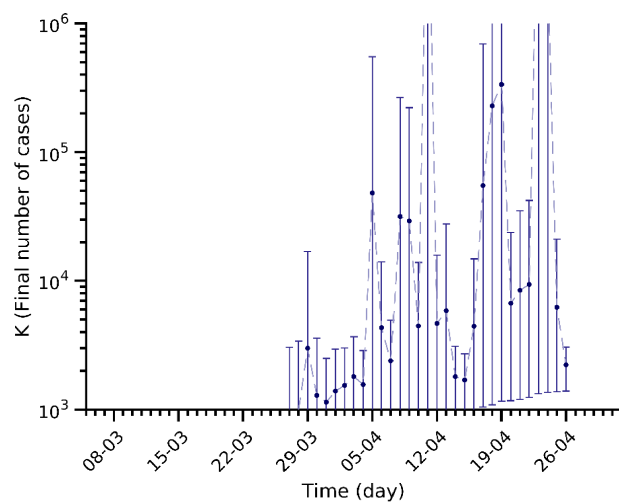
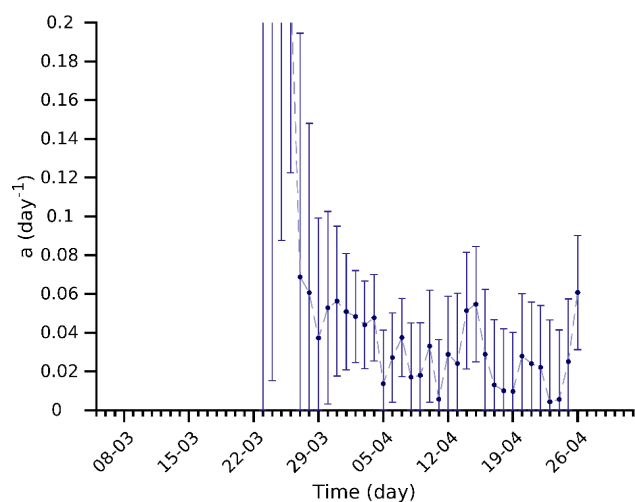
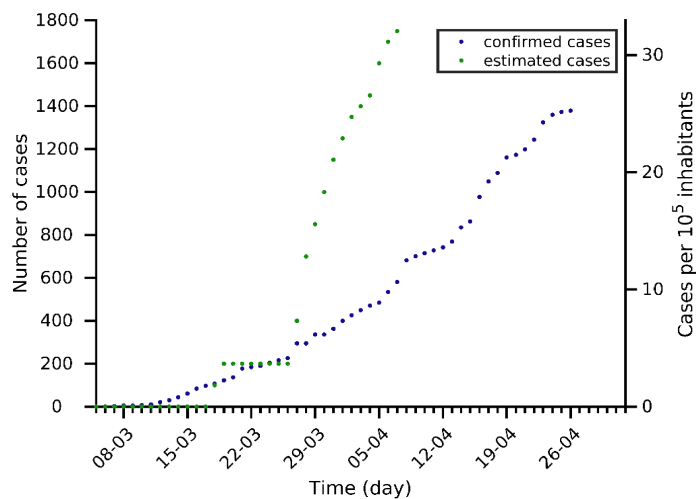
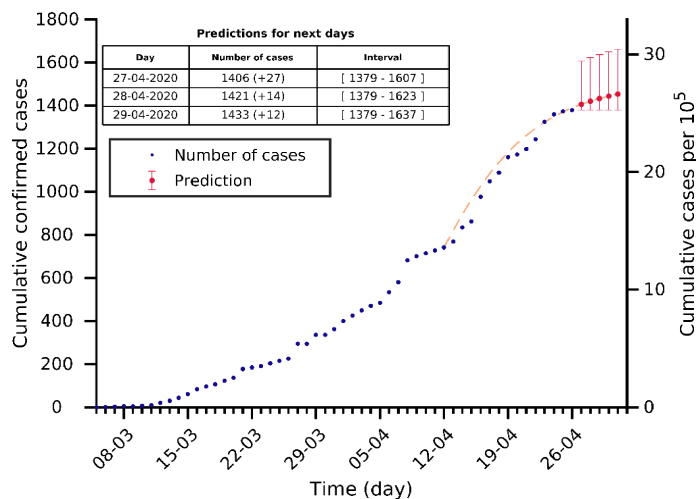




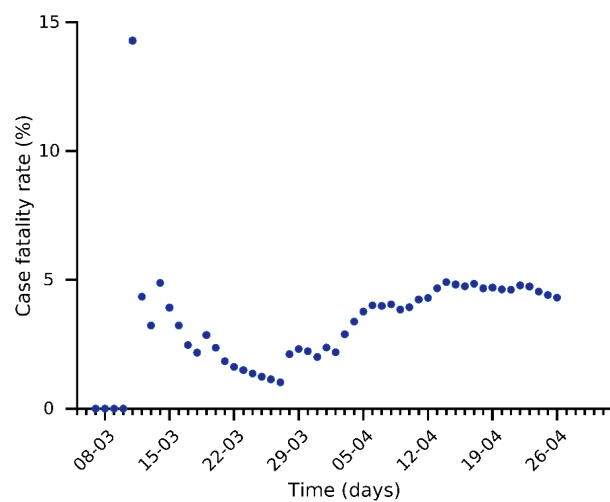
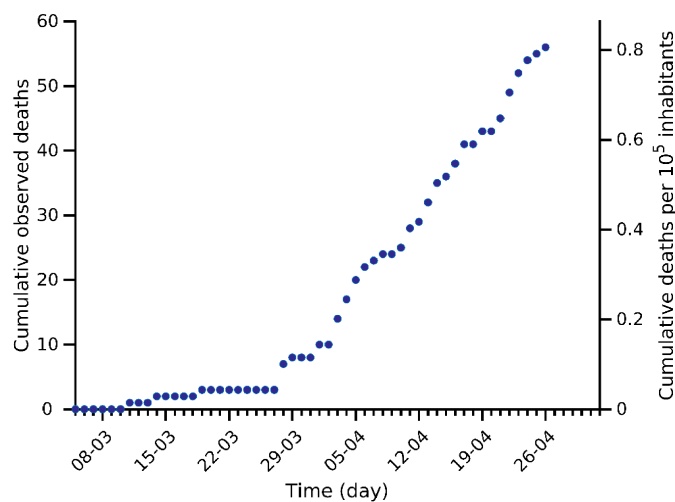
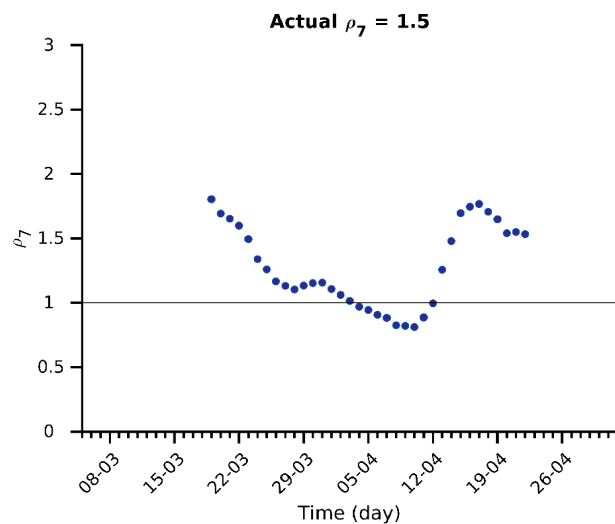
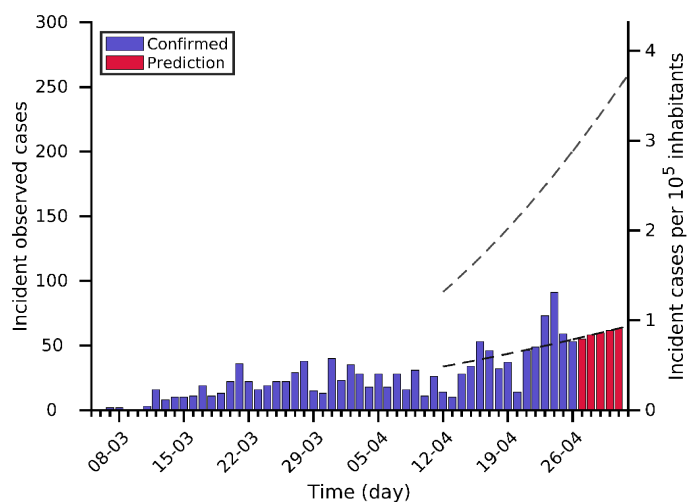
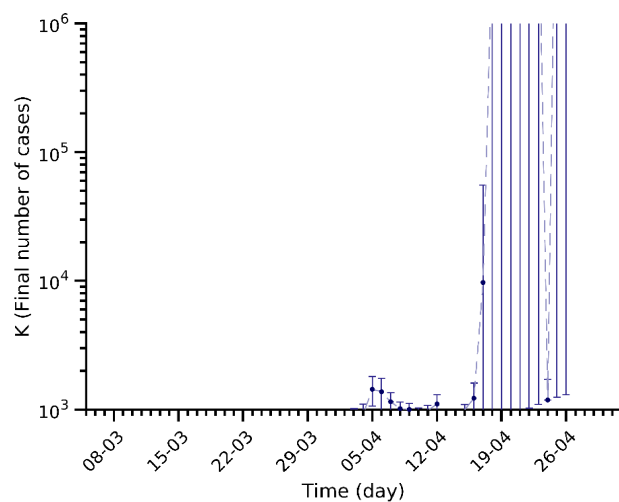
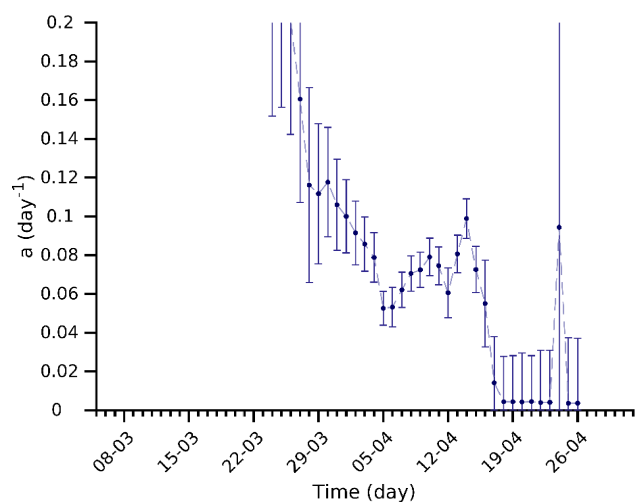
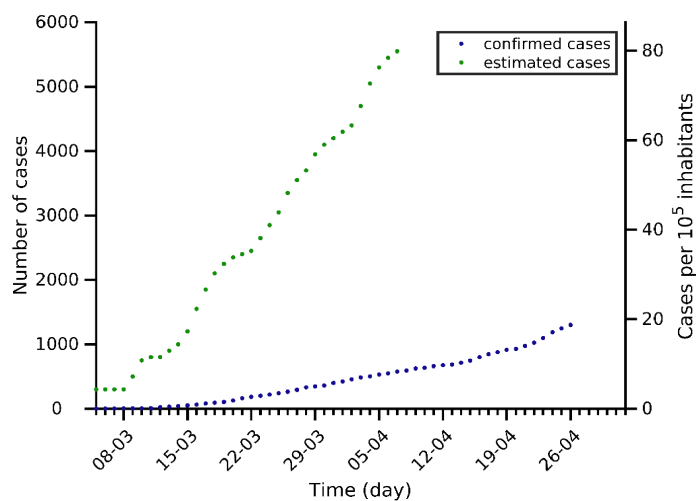
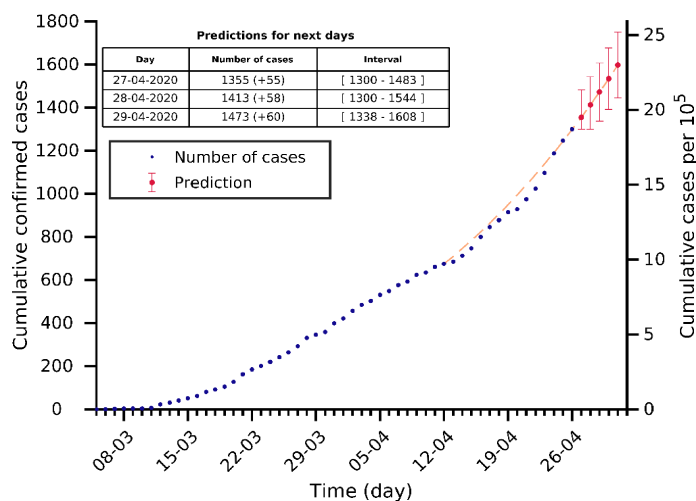
# Slovenia 26-04-2020. Population: 2.1M. Current cumulated incidence: 68/10<sup>5</sup>



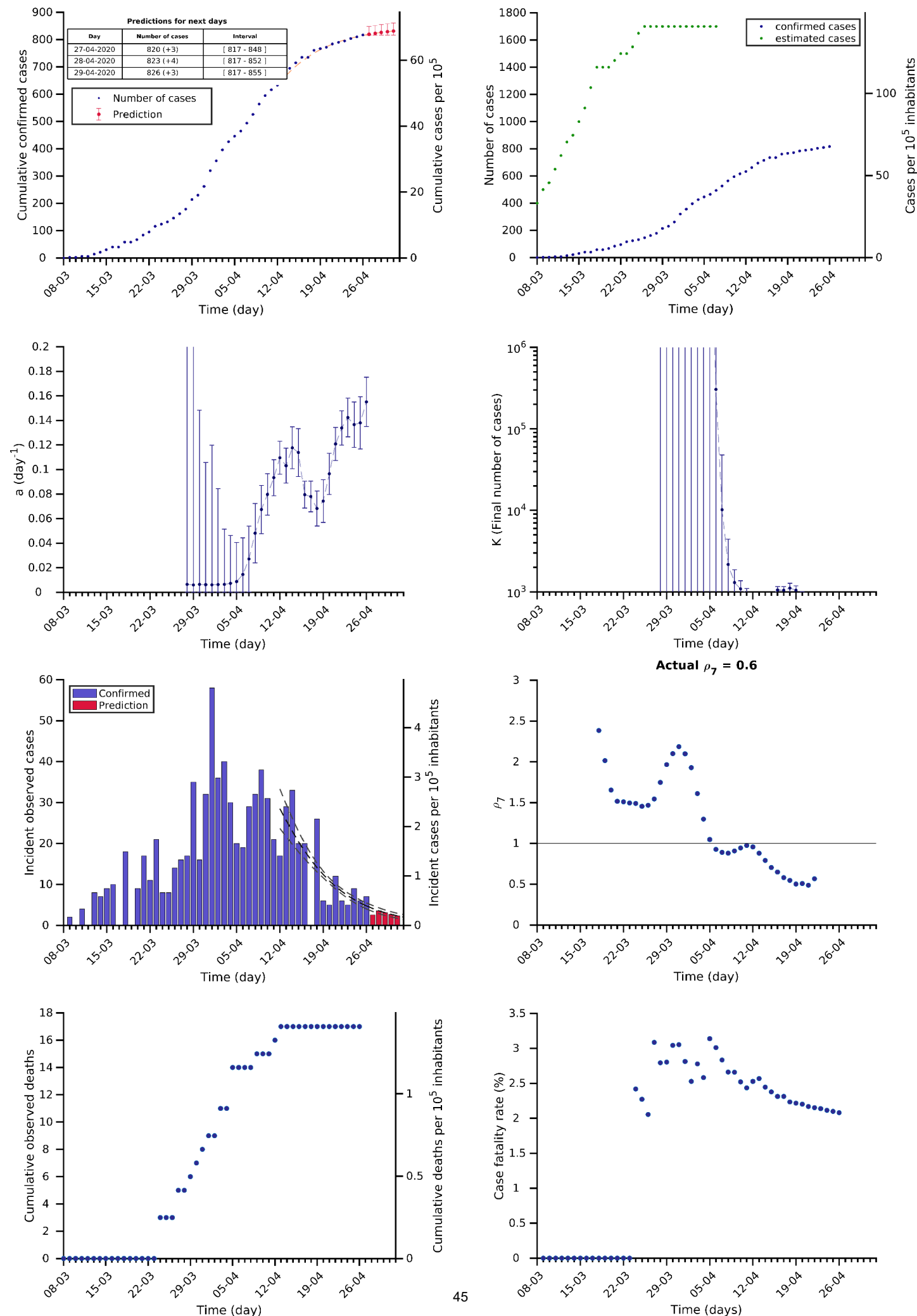
# Slovakia 26-04-2020. Population: 5.5M. Current cumulated incidence: 25/10<sup>5</sup>



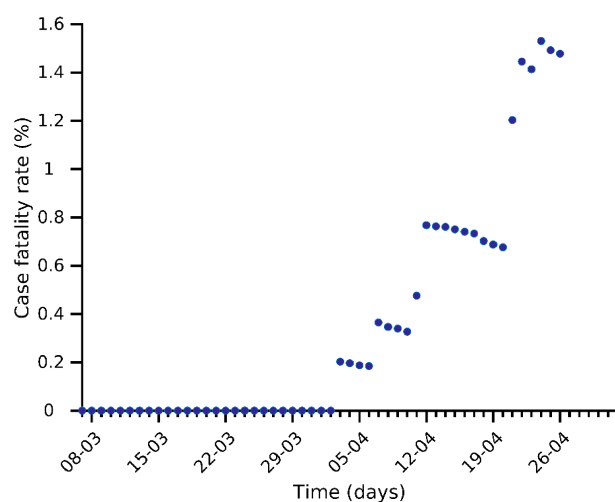
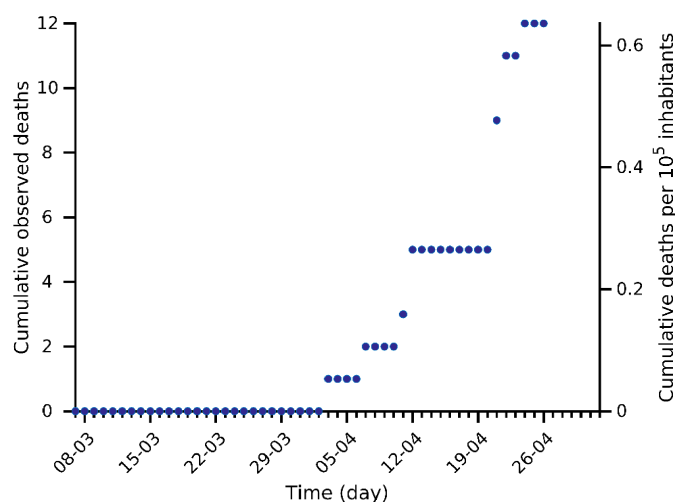
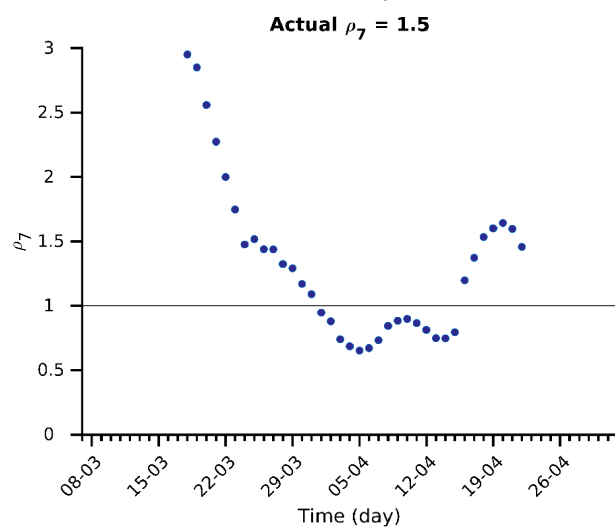
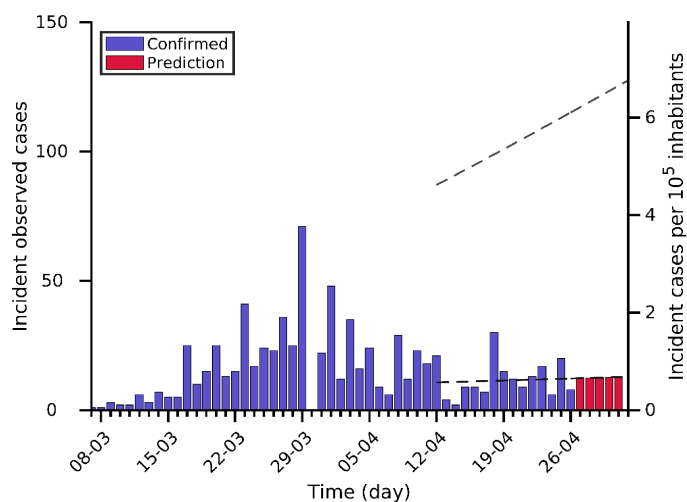
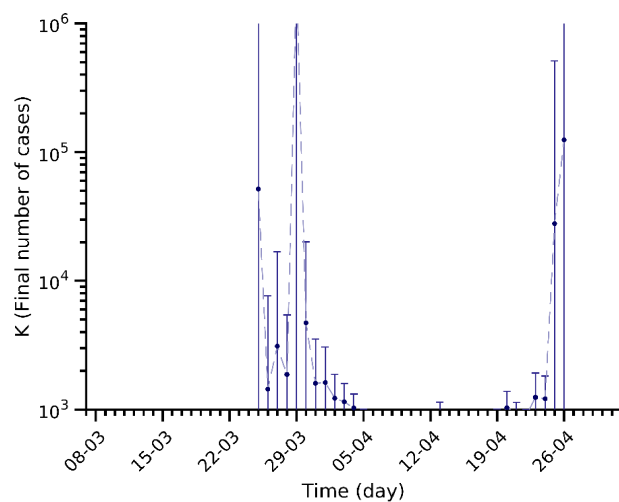
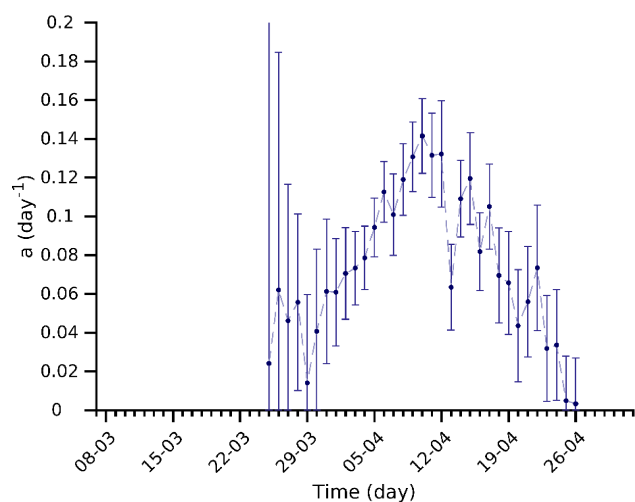
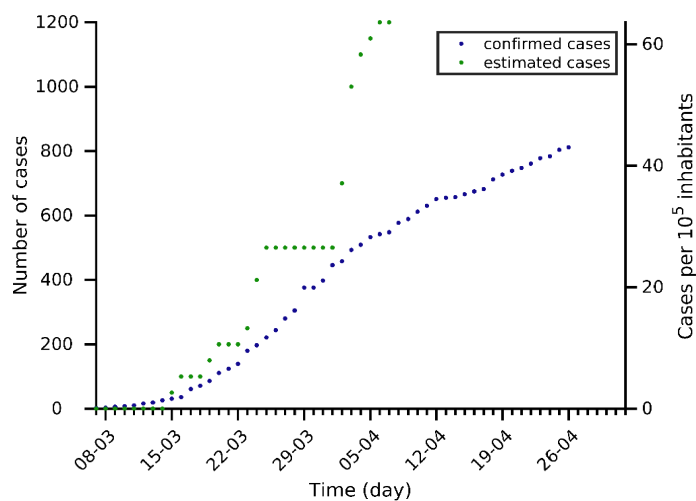
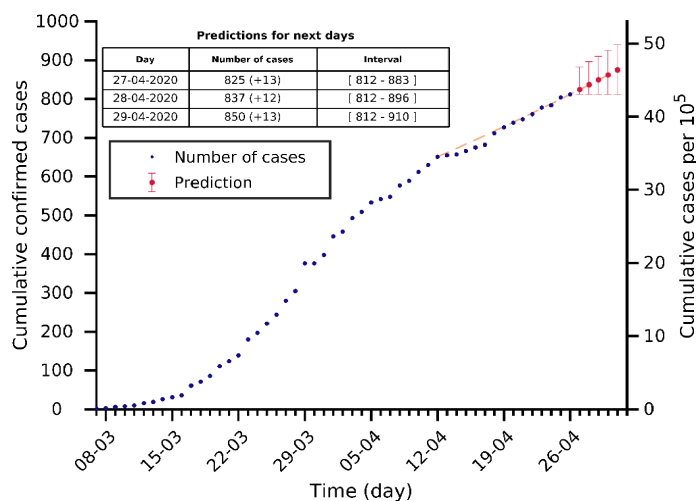
# Bulgaria 26-04-2020. Population: 6.9M. Current cumulated incidence: 19/10<sup>5</sup>



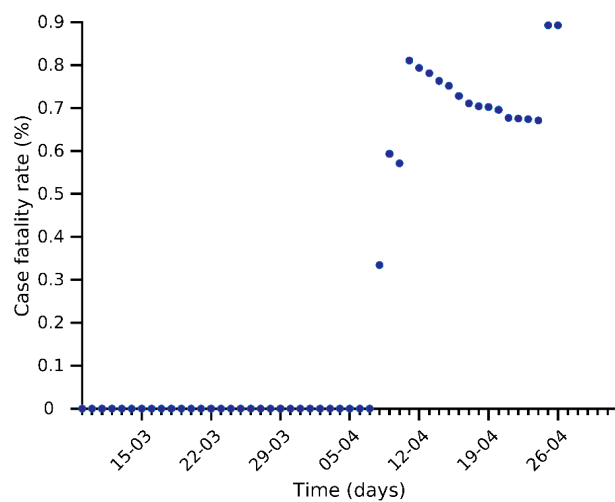
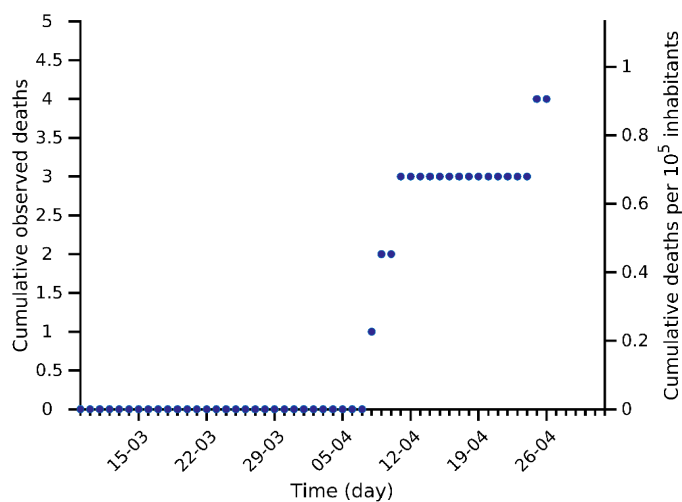
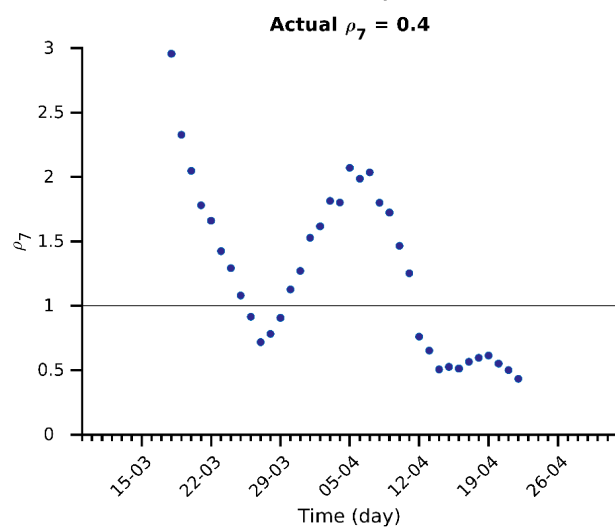
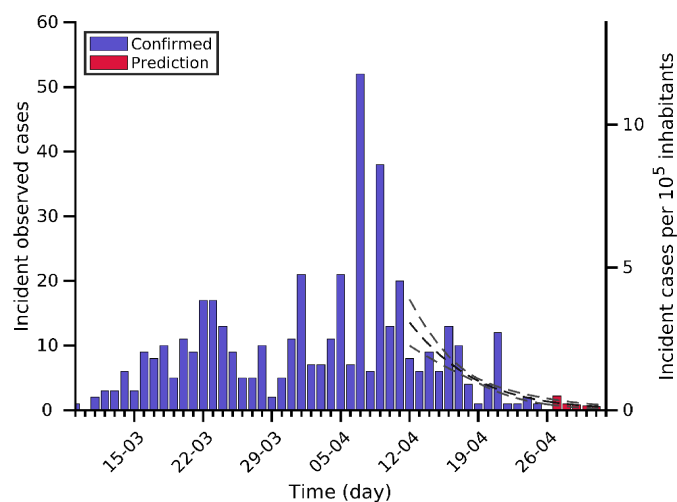
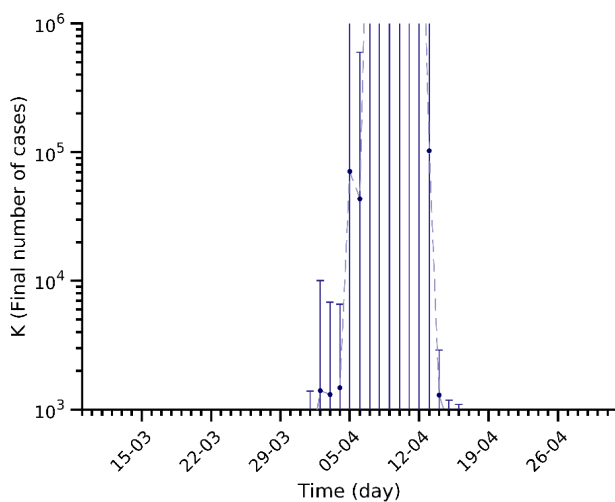
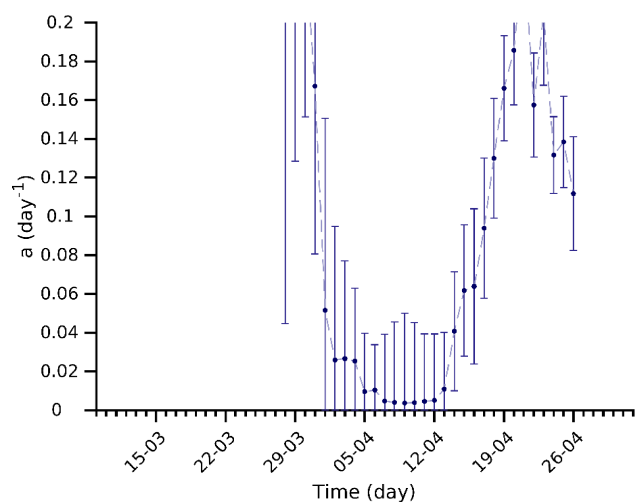
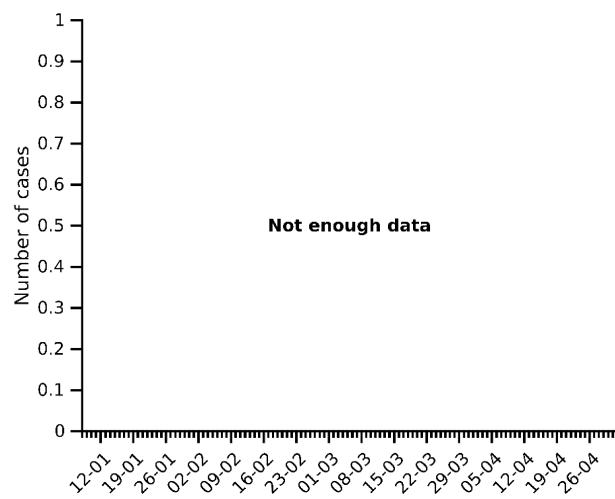
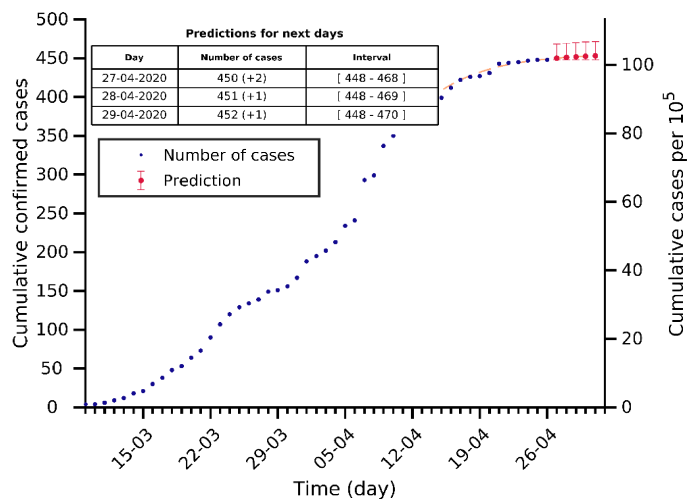
# Cyprus 26-04-2020. Population: 1.2M. Current cumulated incidence: 68/10<sup>5</sup>



# Latvia 26-04-2020. Population: 1.9M. Current cumulated incidence: 43/10<sup>5</sup>



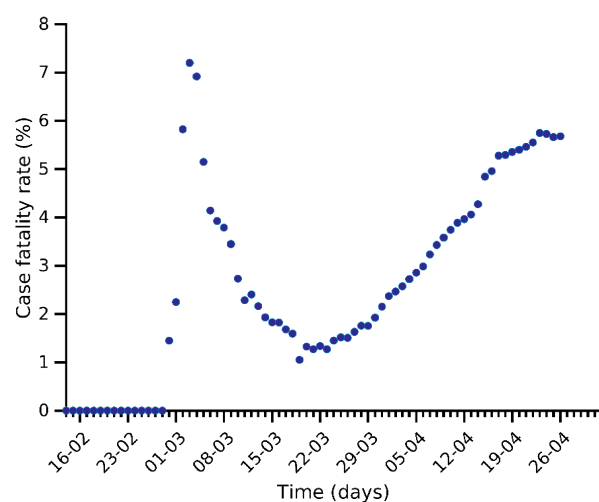
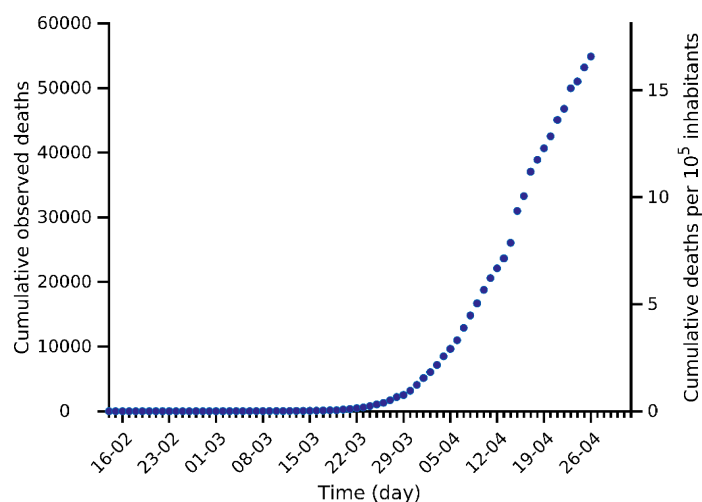
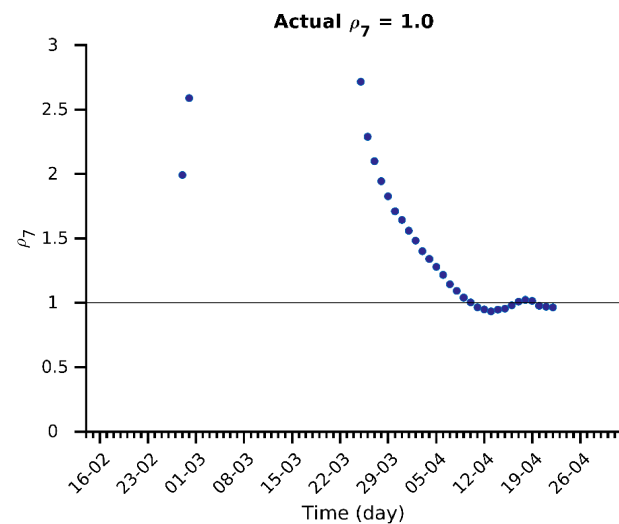
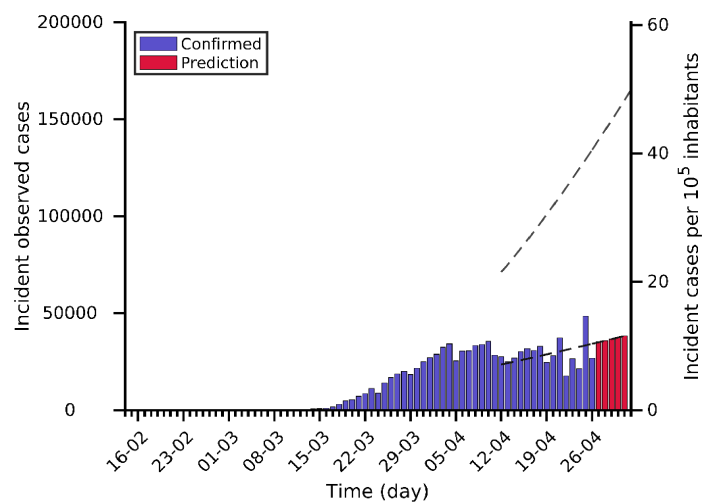
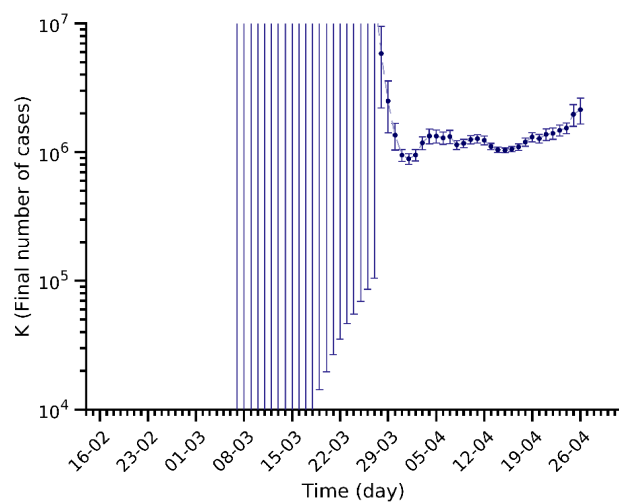
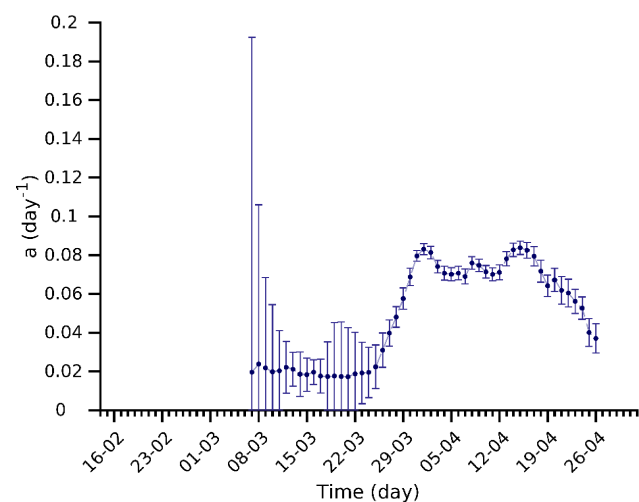
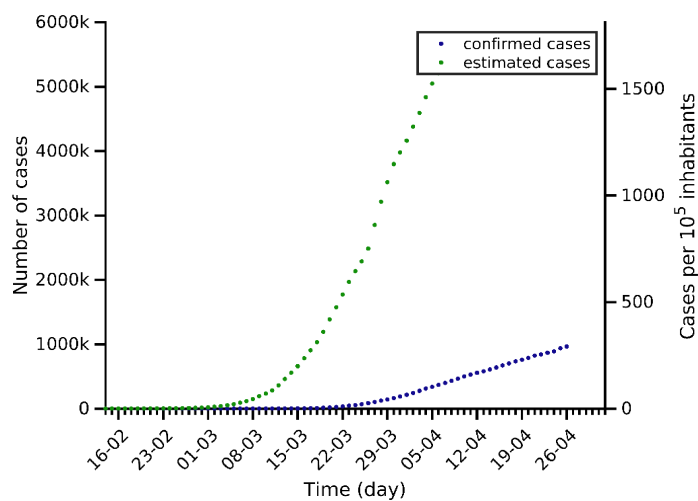
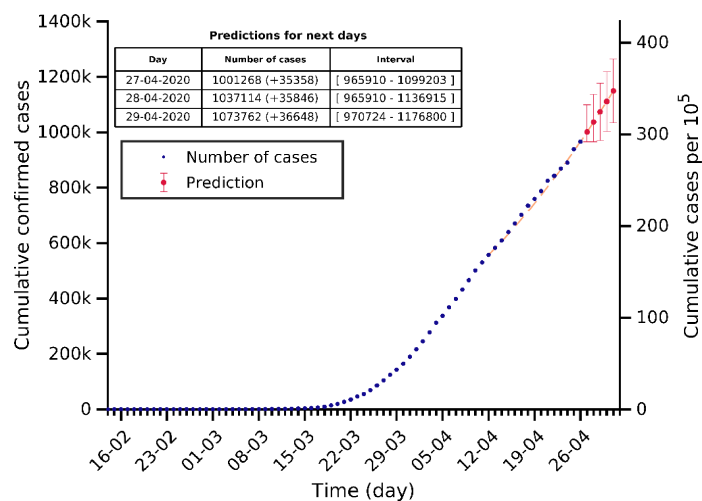
# Malta 26-04-2020. Population: 0.4M. Current cumulated incidence: 101/10<sup>5</sup>



## **(2) Analysis and prediction of COVID-19 for other countries**

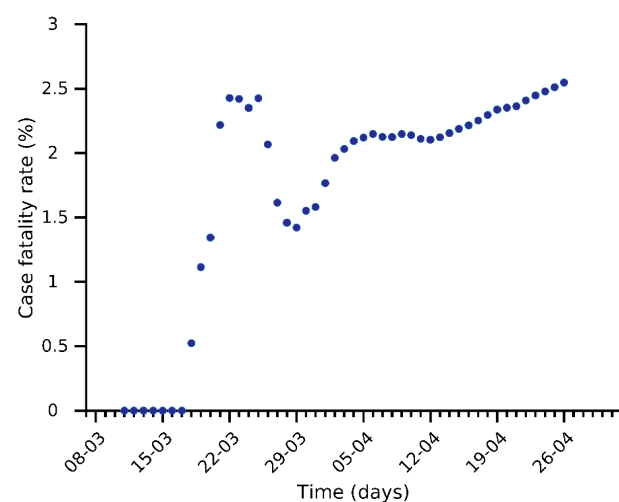
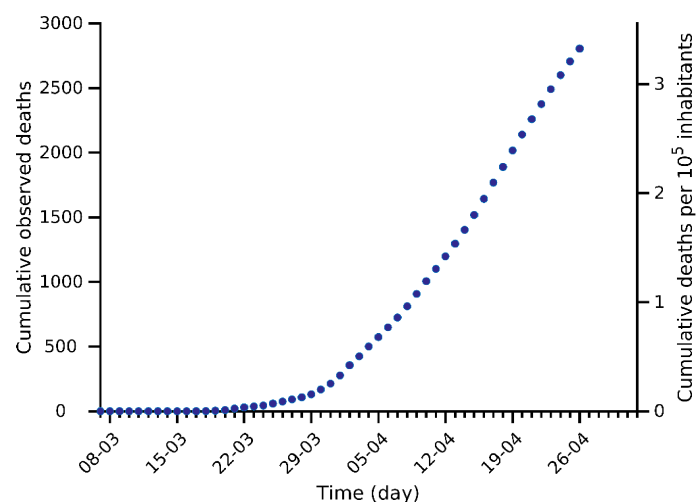
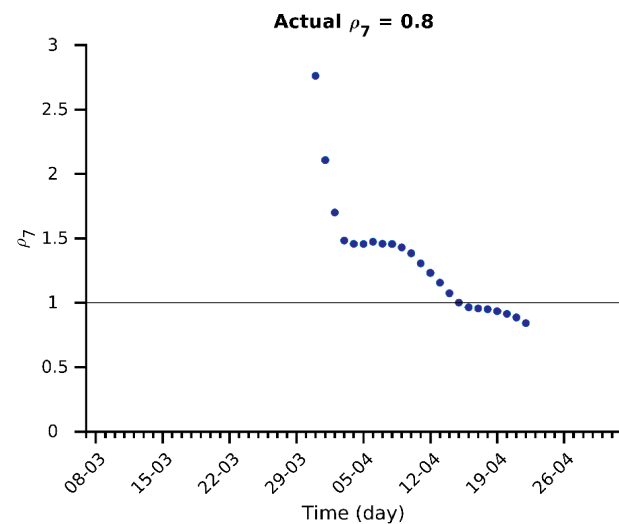
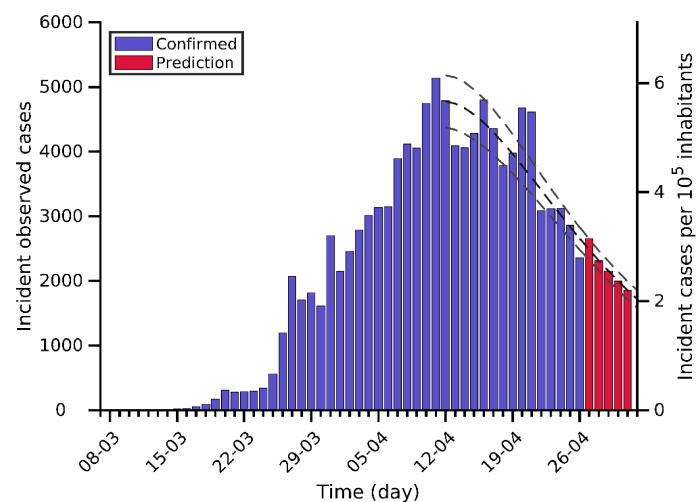
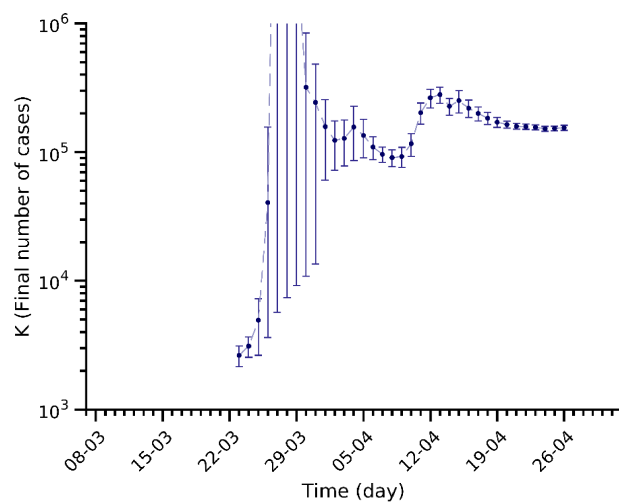
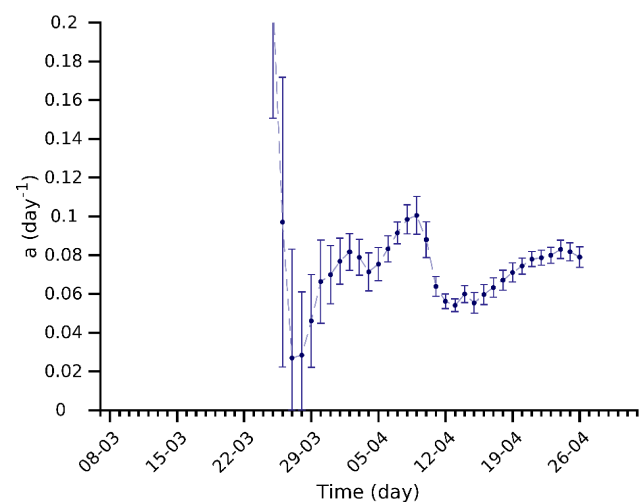
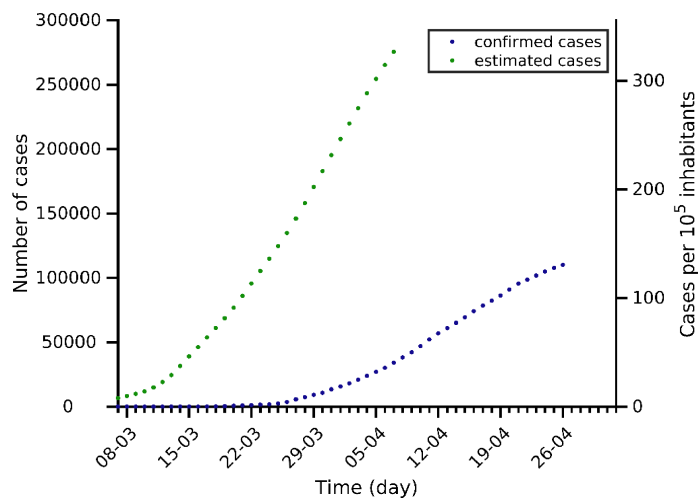
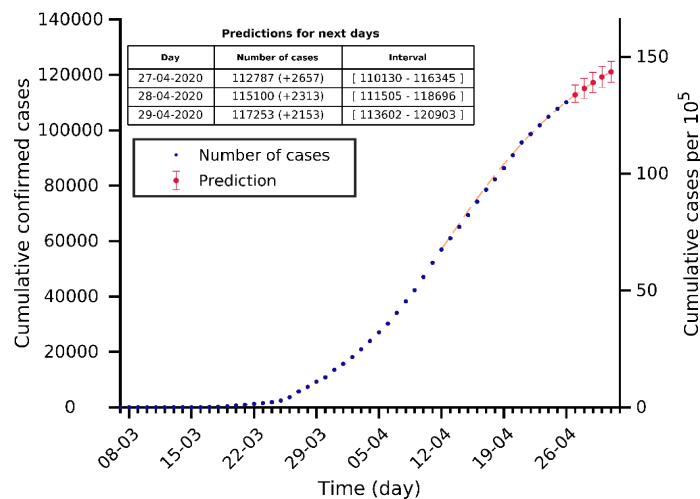
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

# USA 26-04-2020. Population: 331.0M. Current cumulated incidence: 292/10<sup>5</sup>

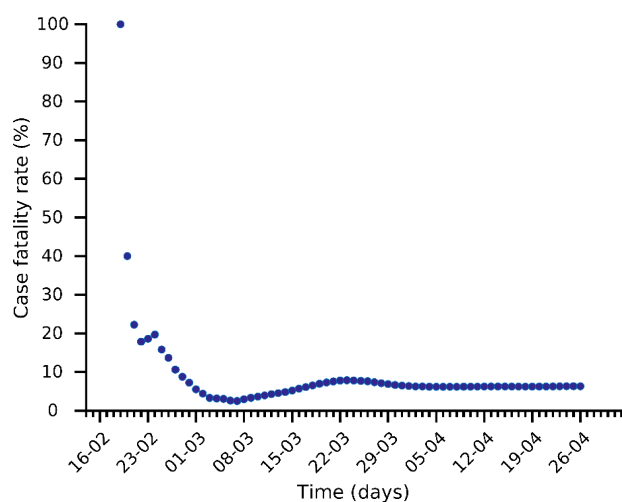
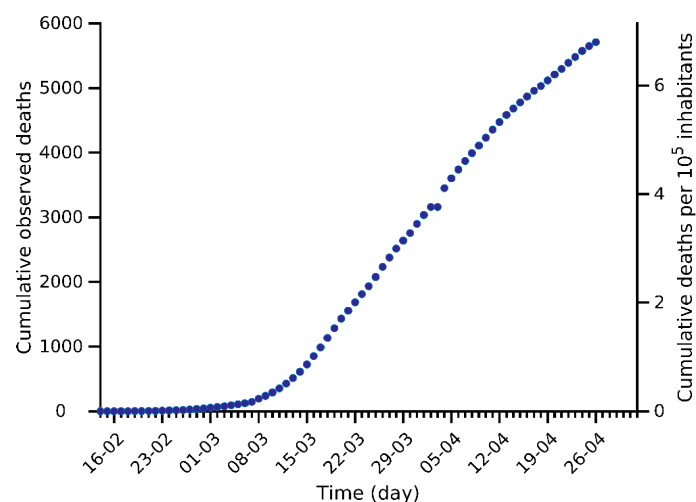
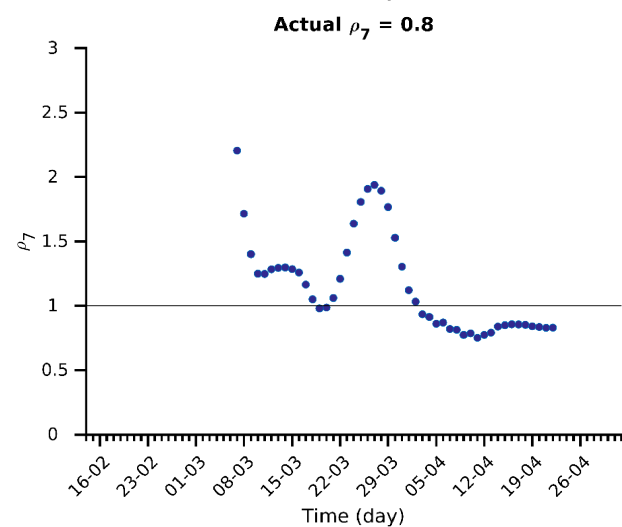
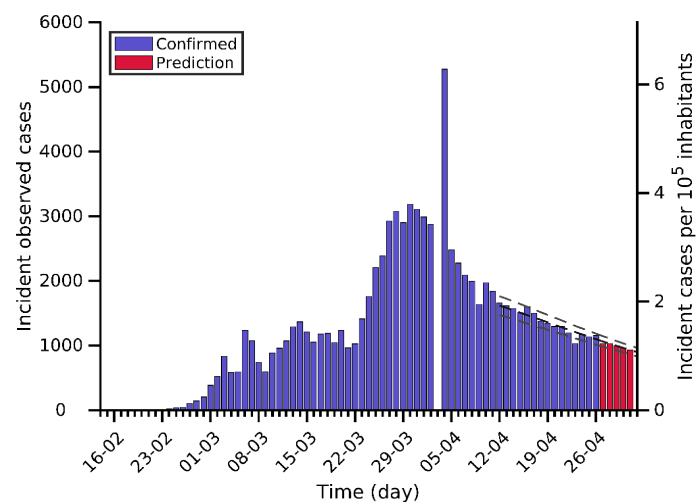
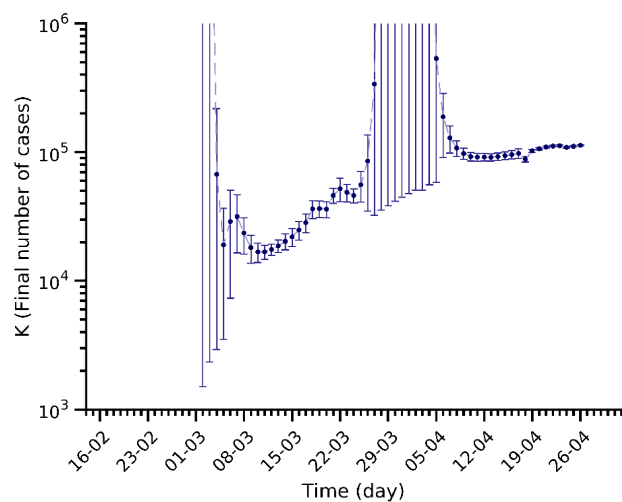
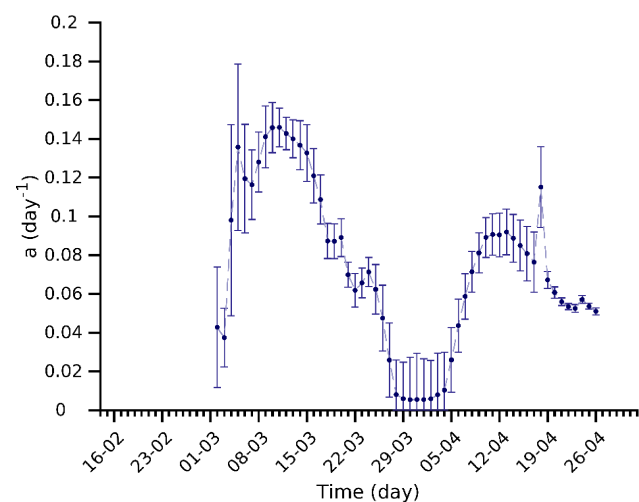
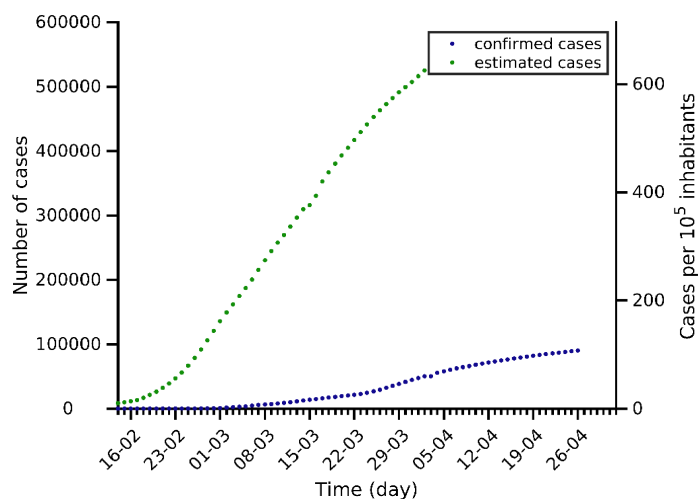
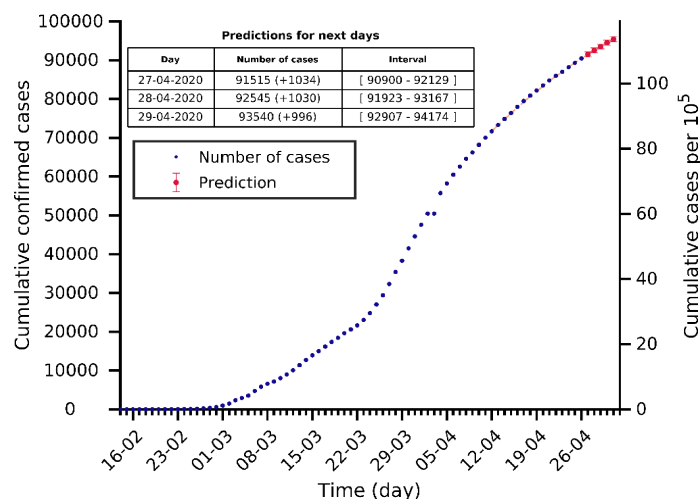




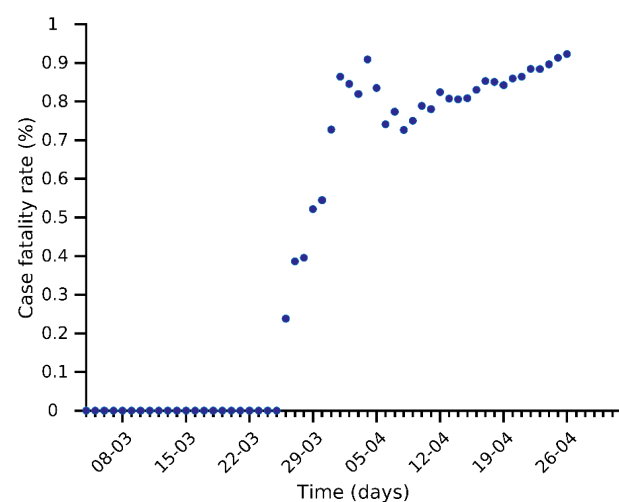
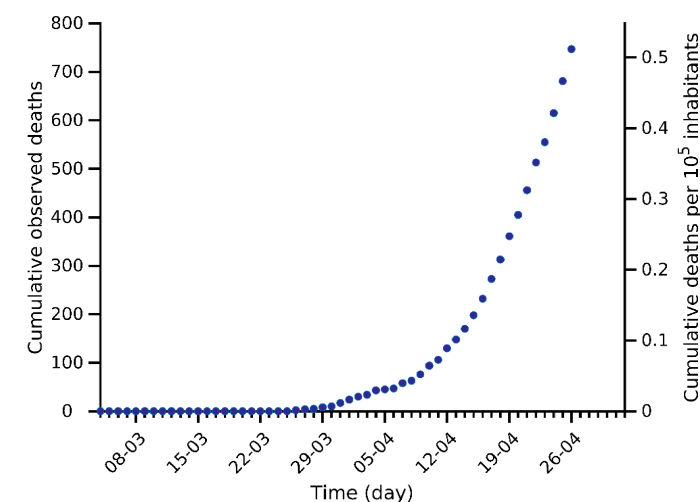
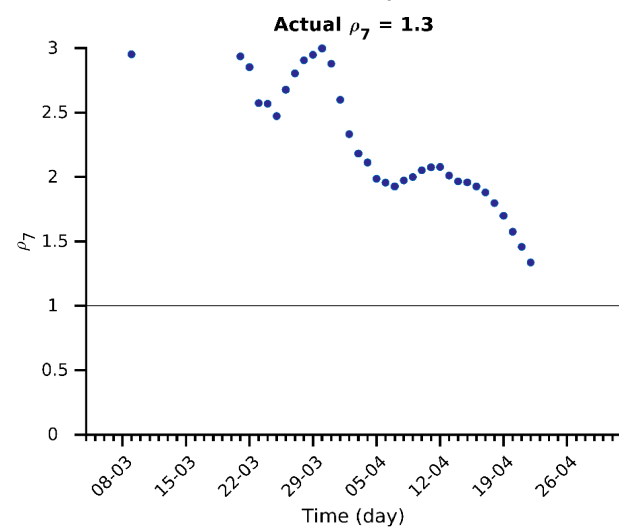
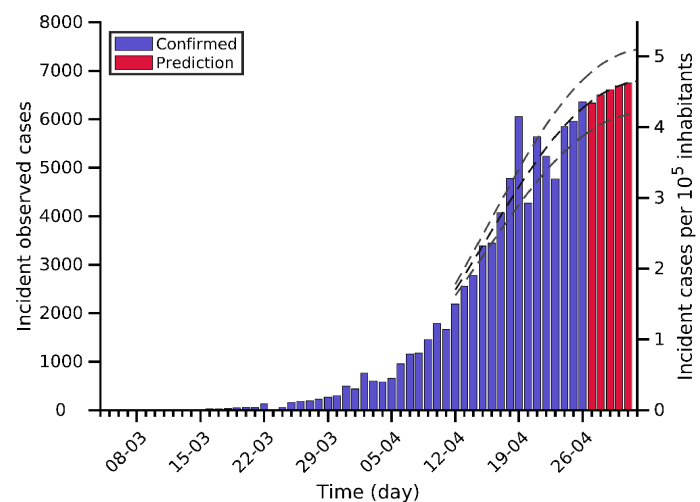
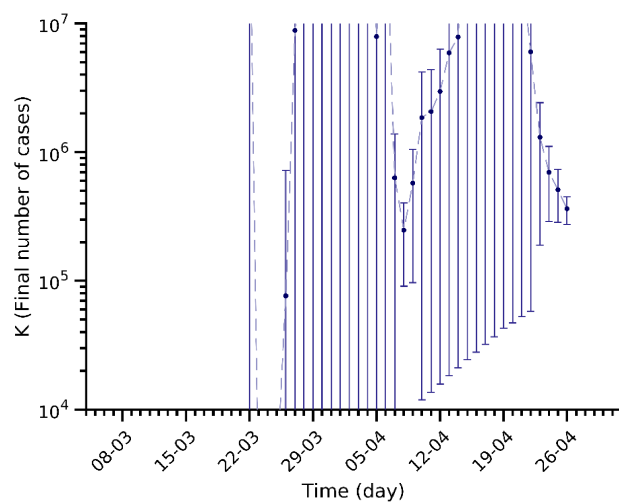
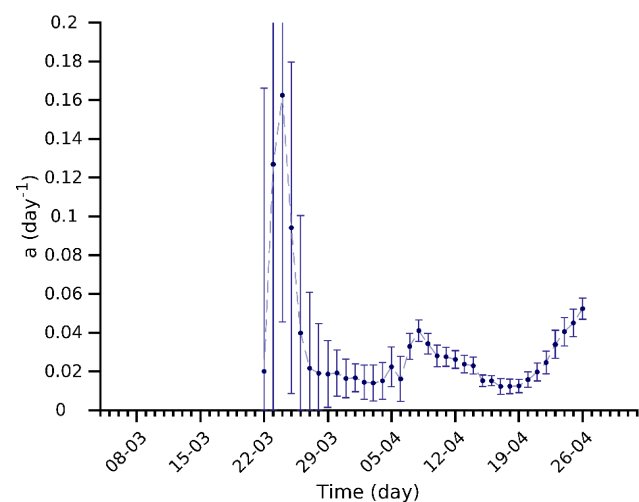
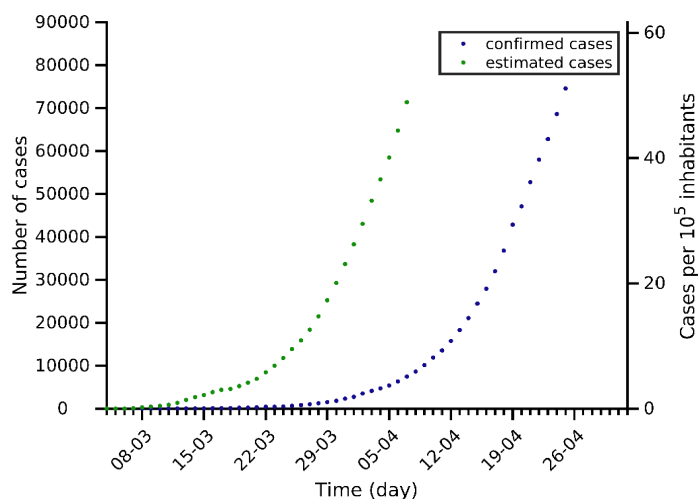
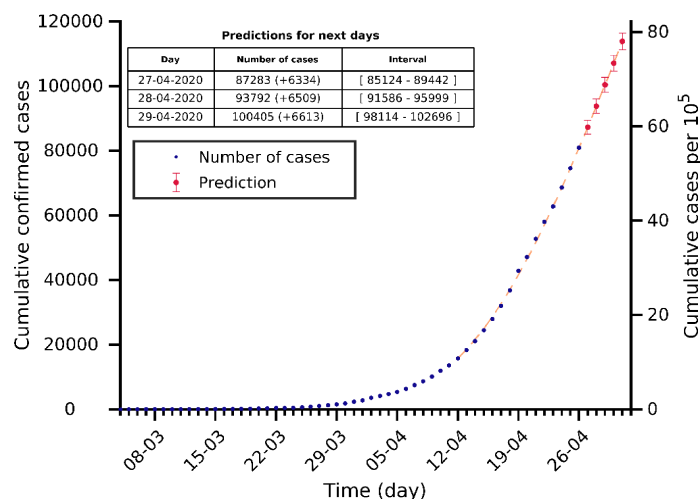
# Turkey 26-04-2020. Population: 84.3M. Current cumulated incidence: 131/10<sup>5</sup>



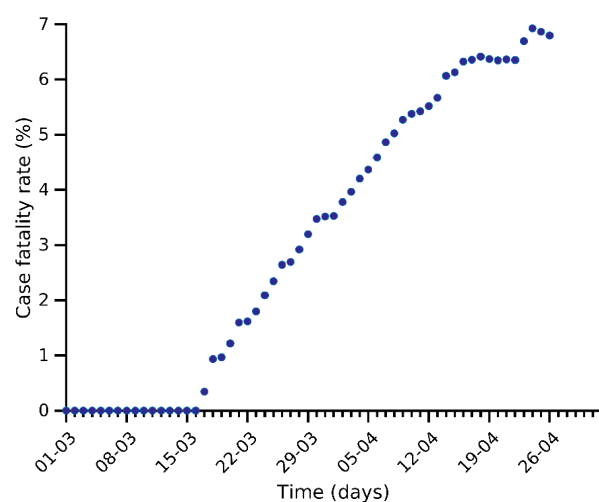
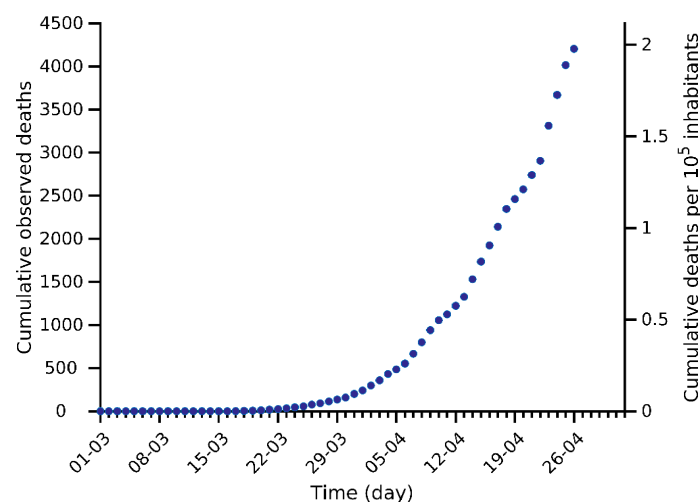
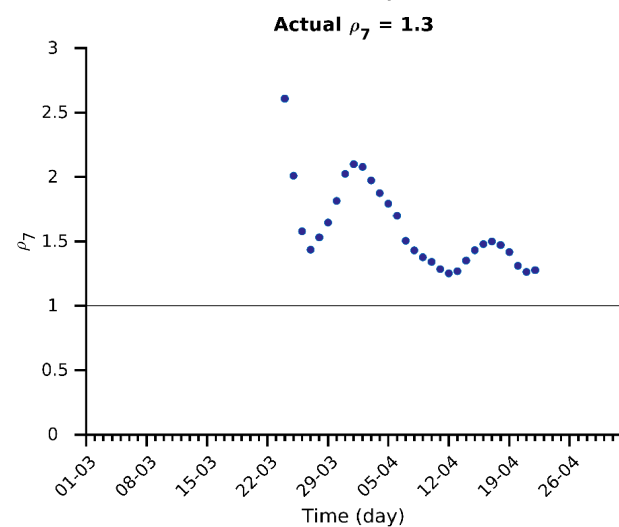
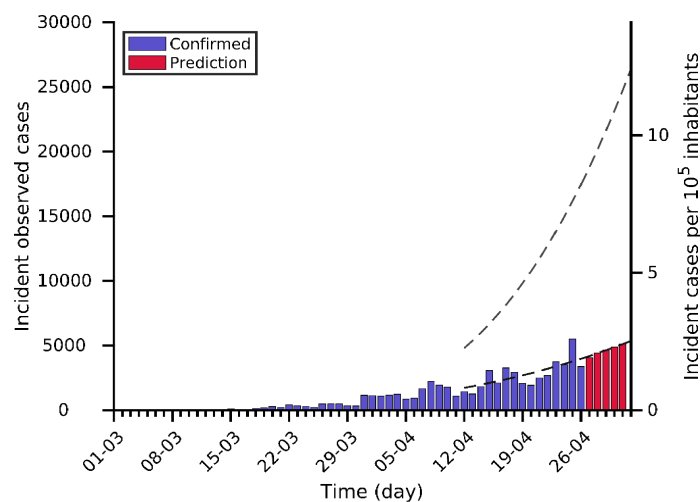
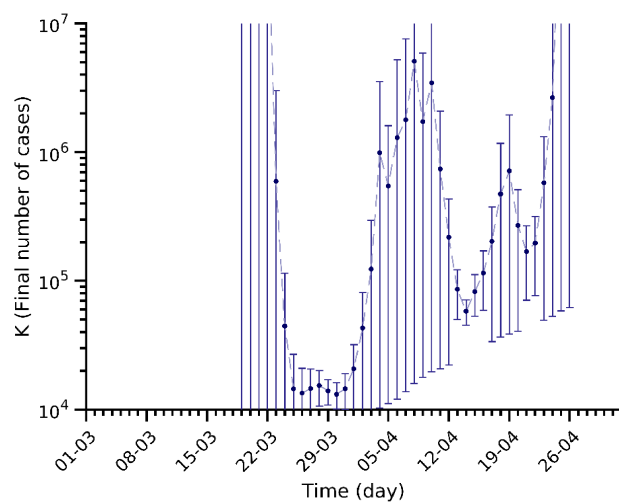
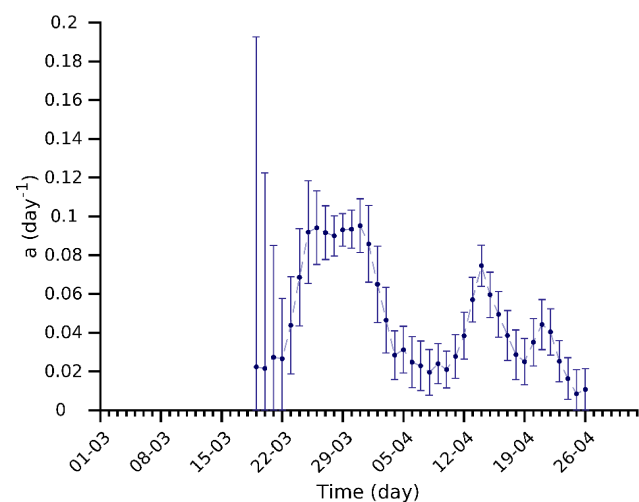
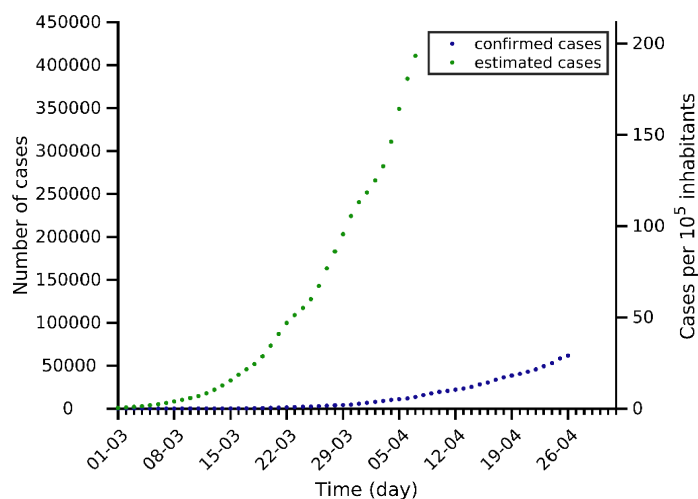
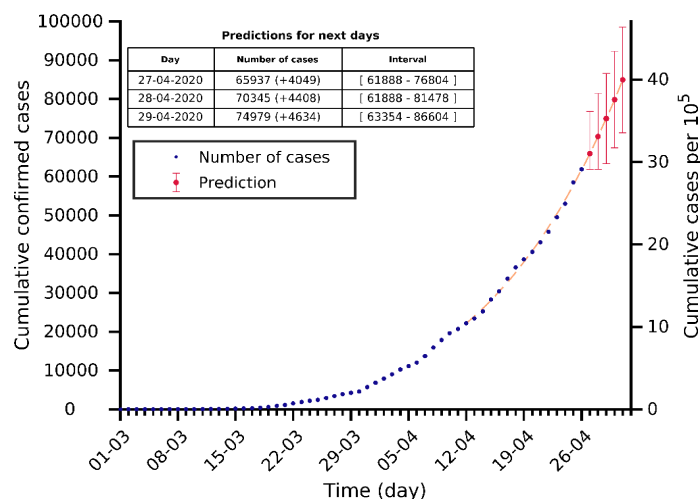
# Iran 26-04-2020. Population: 84.0M. Current cumulated incidence: 108/10<sup>5</sup>



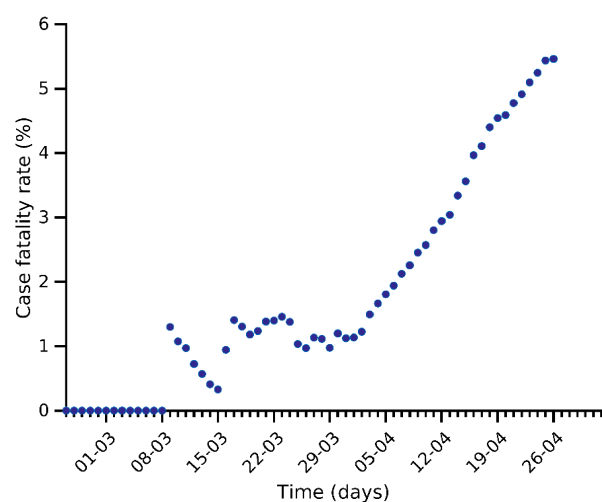
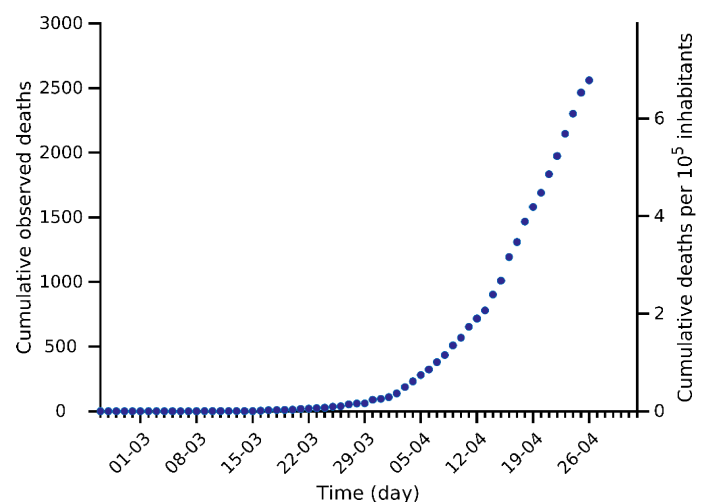
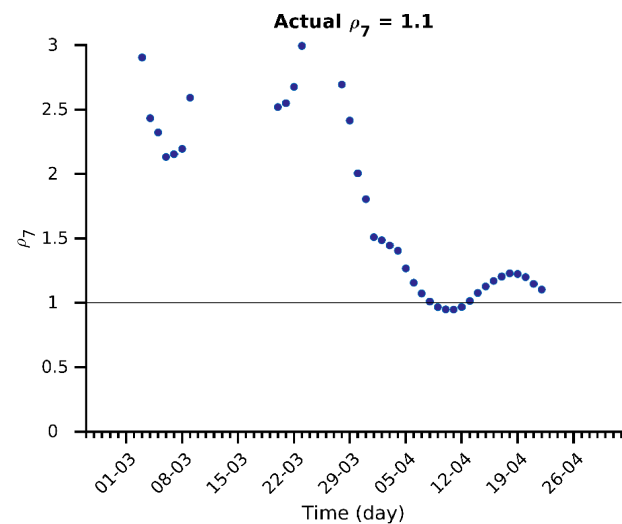
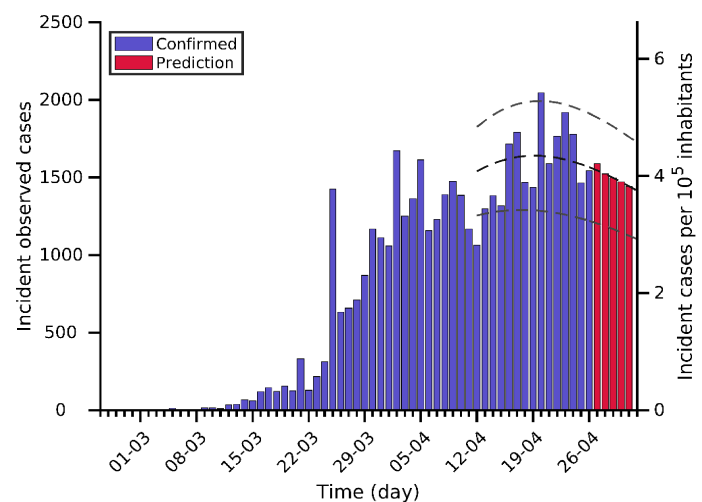
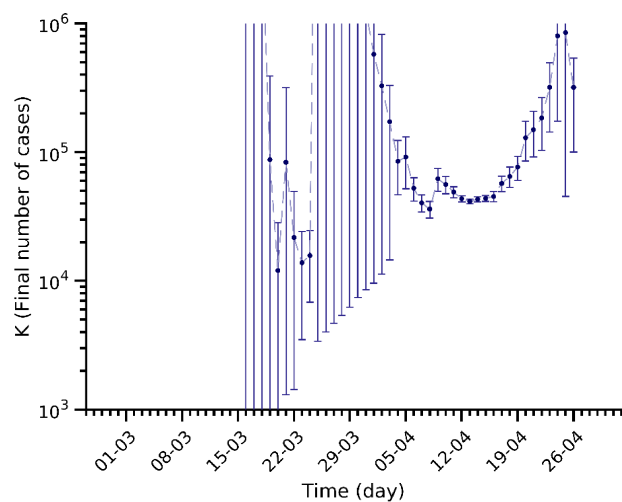
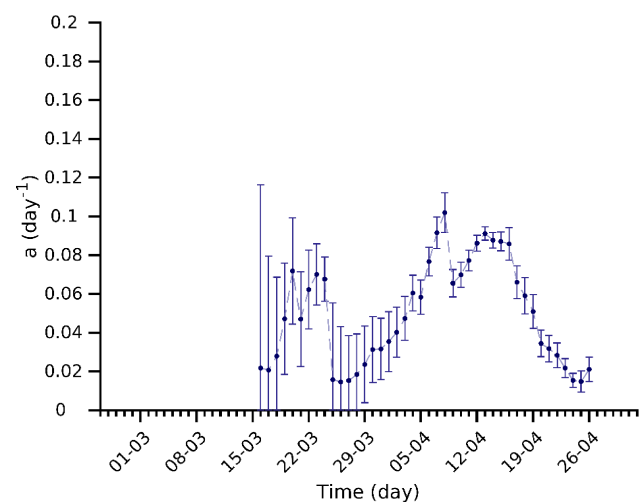
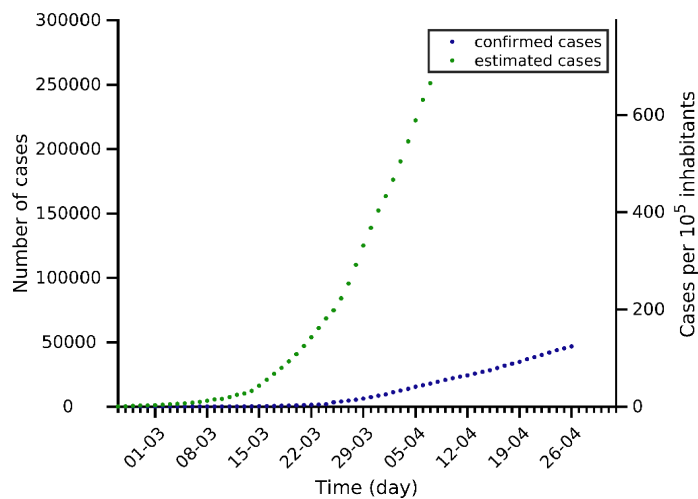
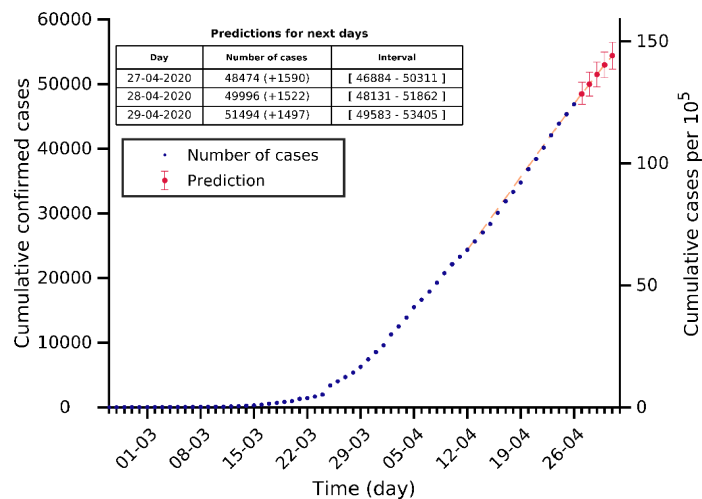
# Russia 26-04-2020. Population: 145.9M. Current cumulated incidence: 55/10<sup>5</sup>

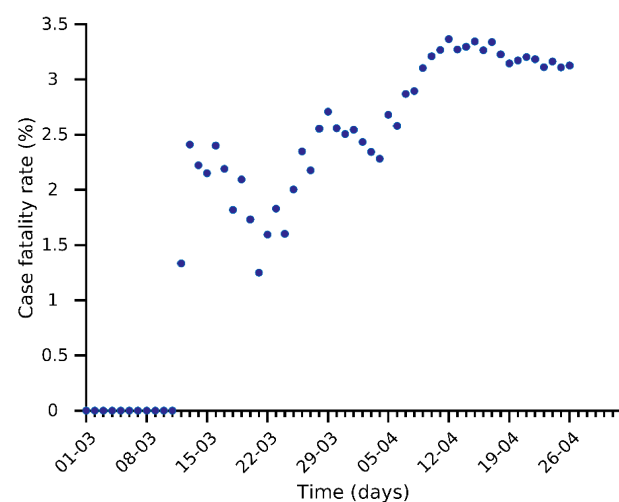
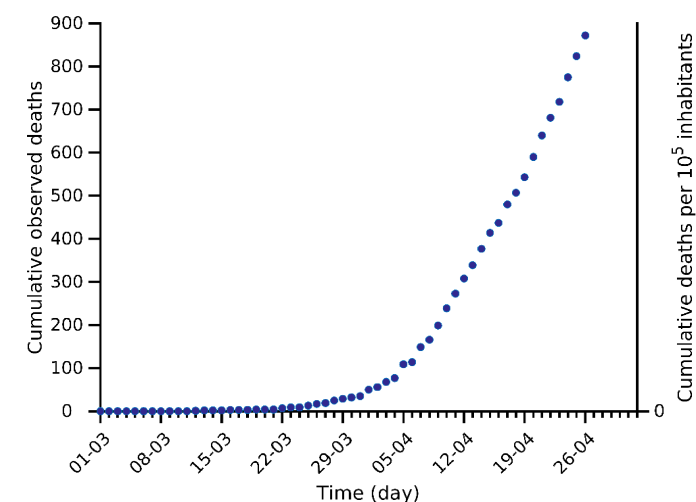
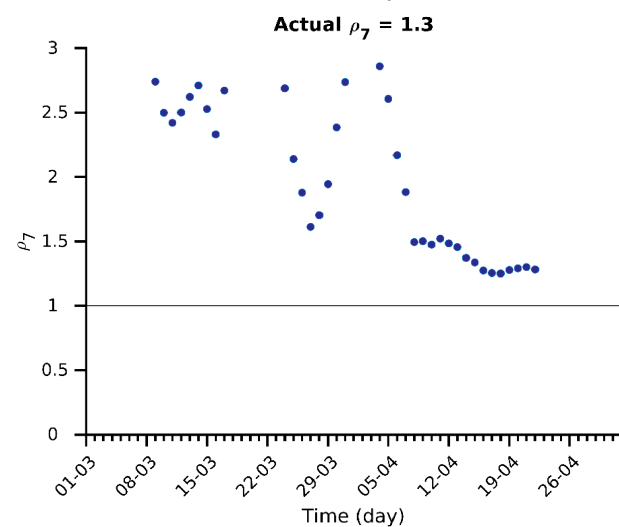
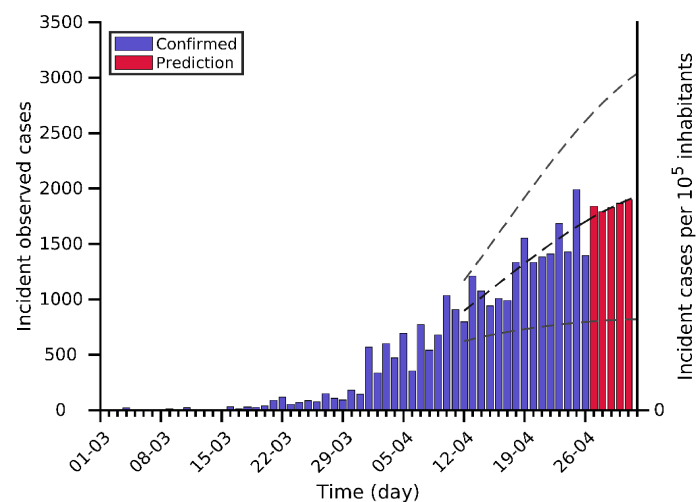
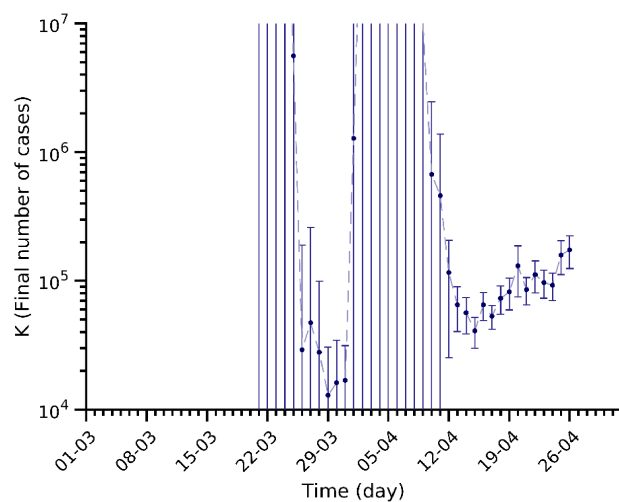
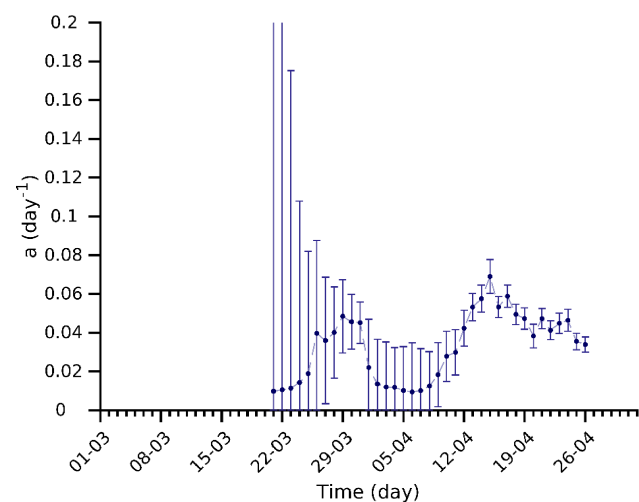
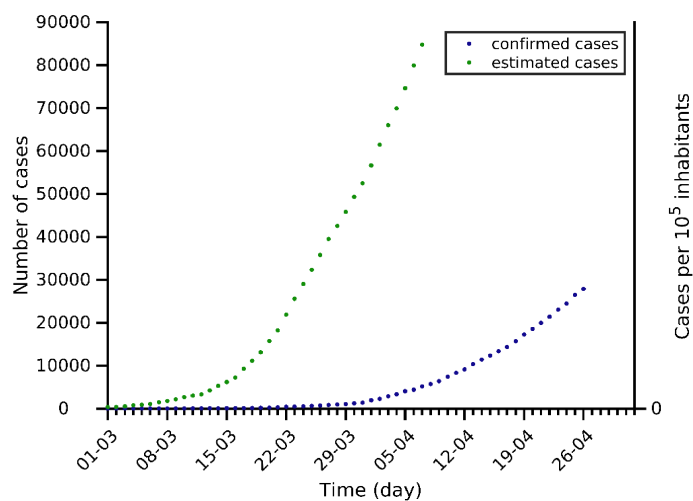
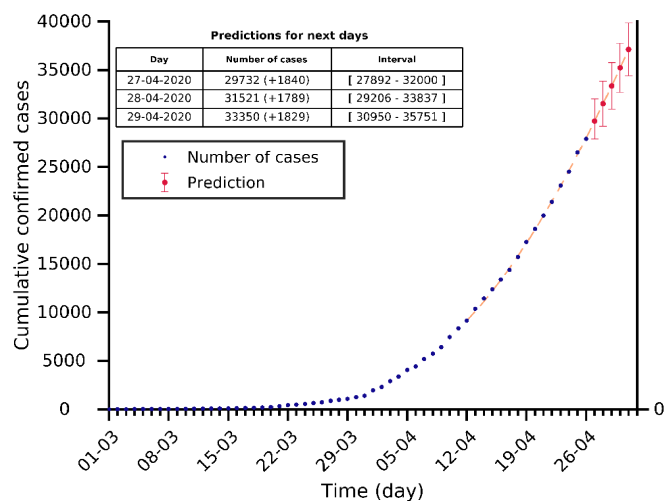


# Brazil 26-04-2020. Population: 212.6M. Current cumulated incidence: 29/10<sup>5</sup>

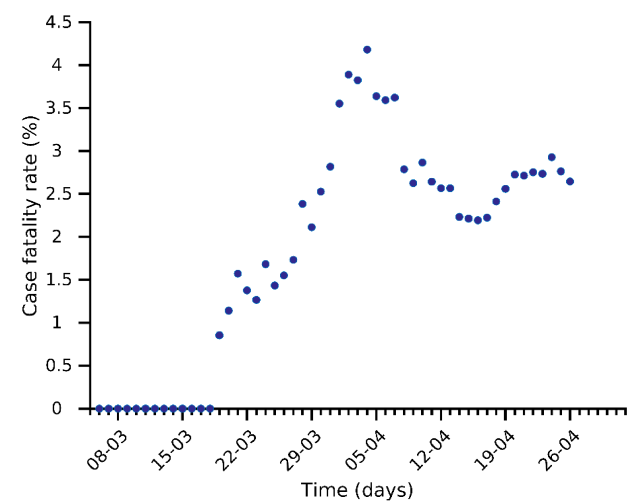
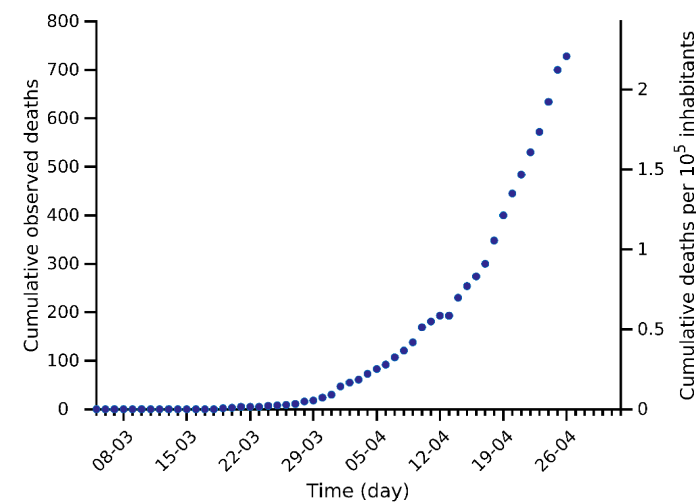
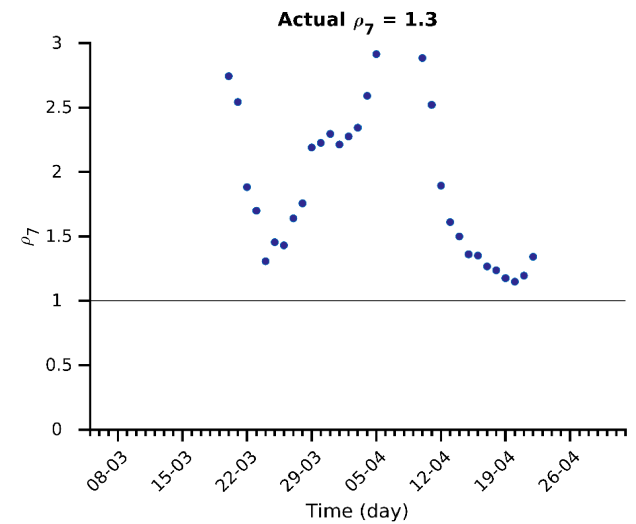
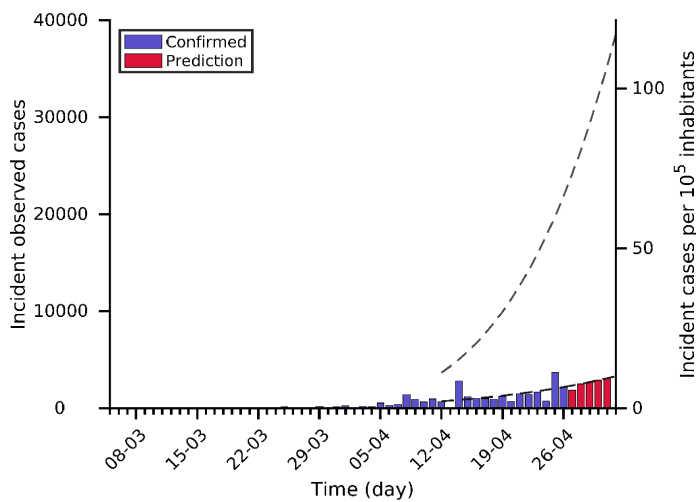
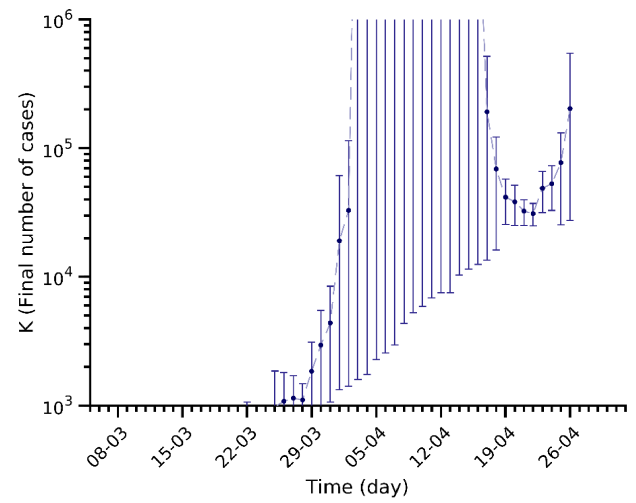
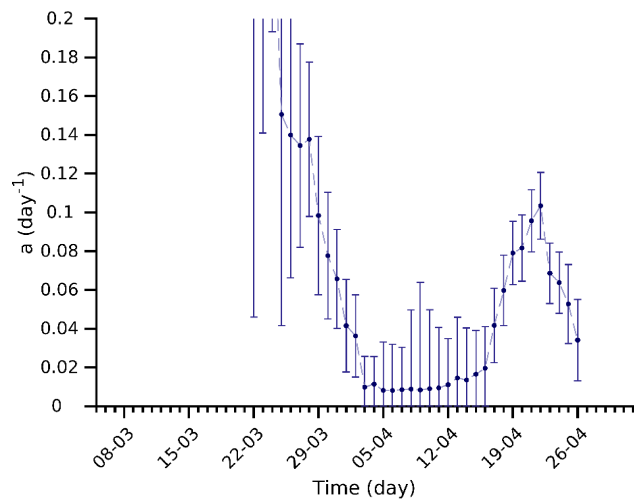
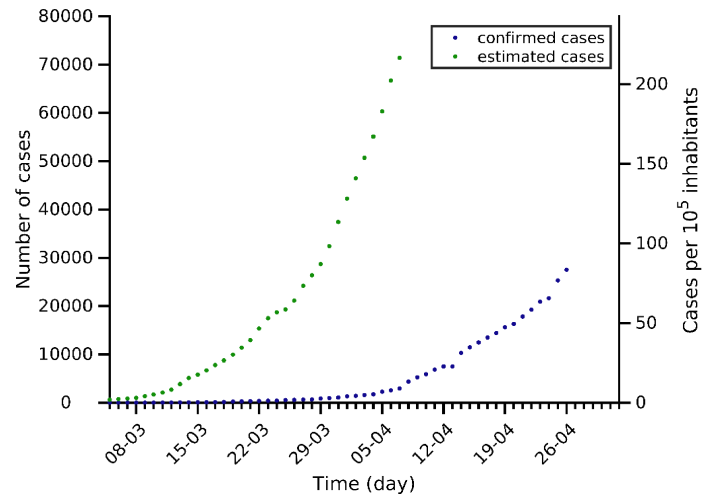
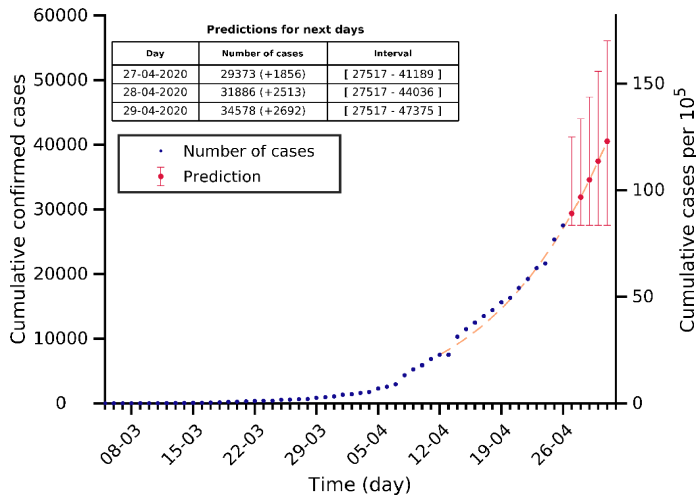


# Canada 26-04-2020. Population: 37.7M. Current cumulated incidence: 124/10<sup>5</sup>

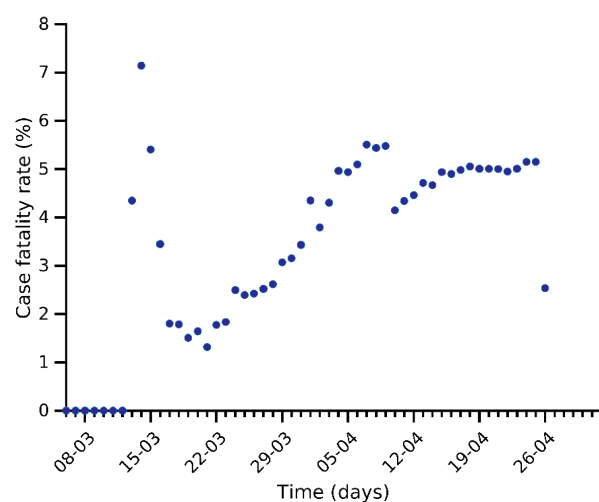
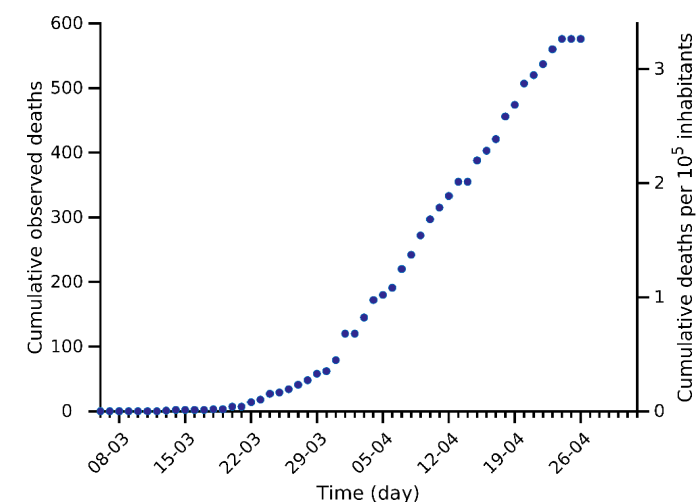
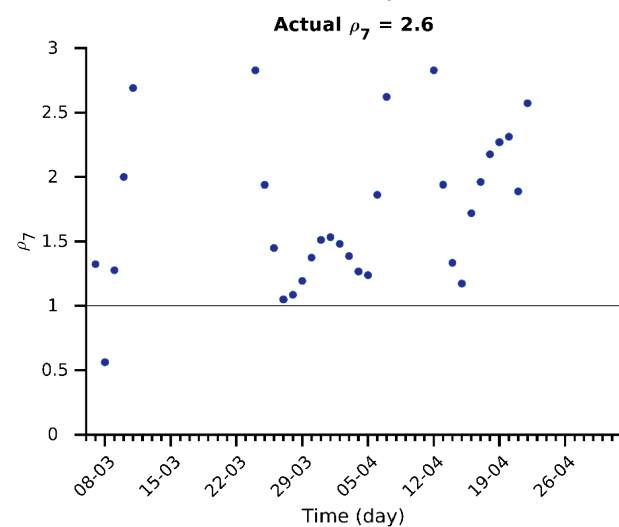
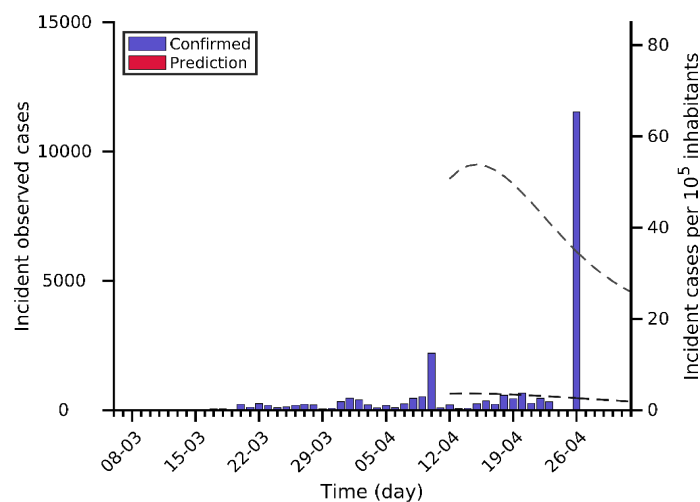
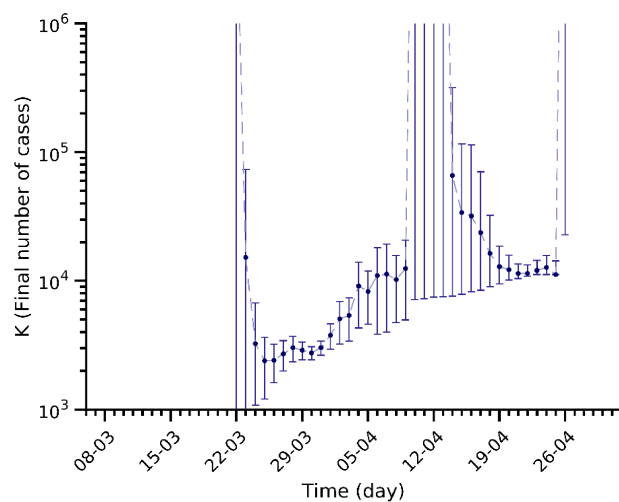
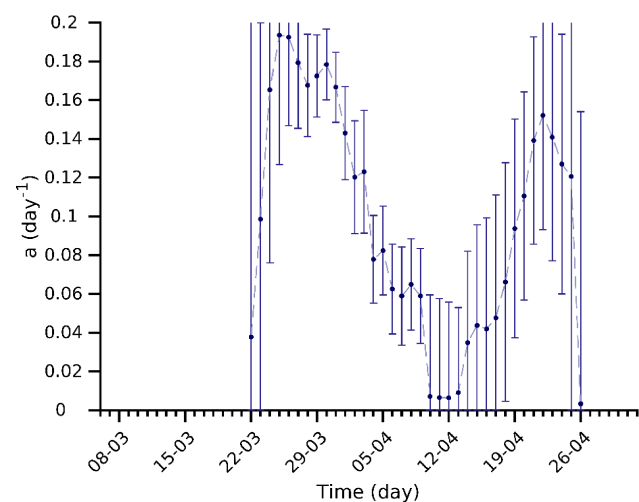
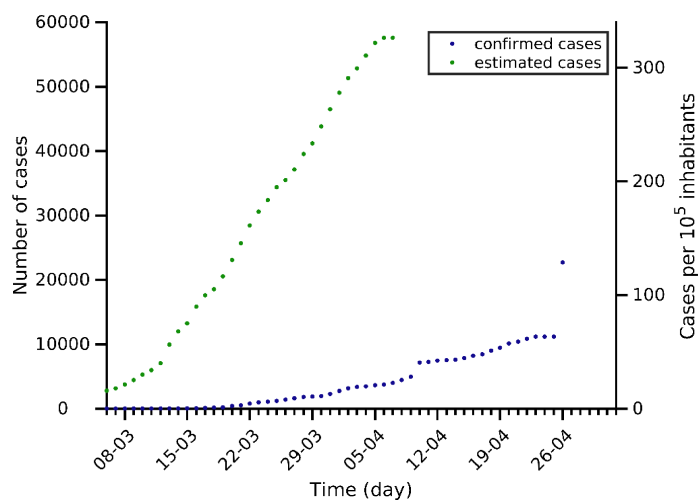
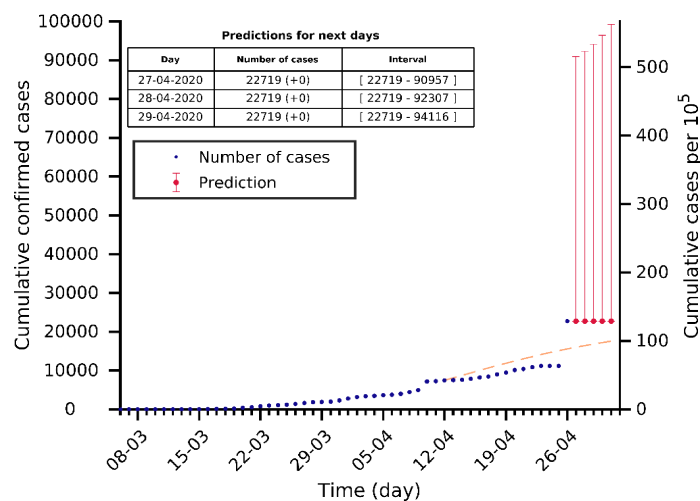




# Peru 26-04-2020. Population: 33.0M. Current cumulated incidence: 83/10<sup>5</sup>

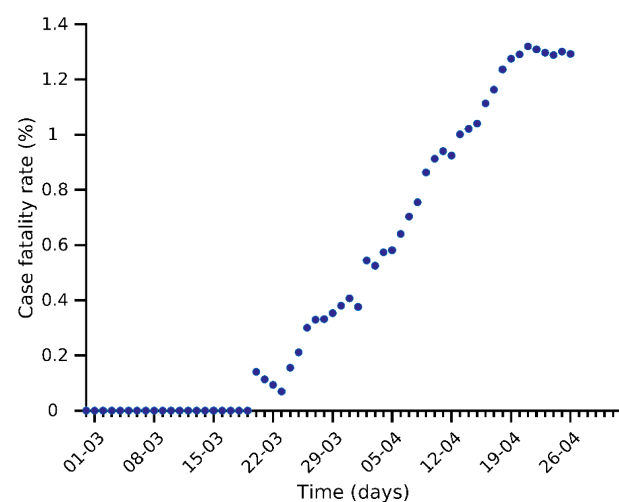
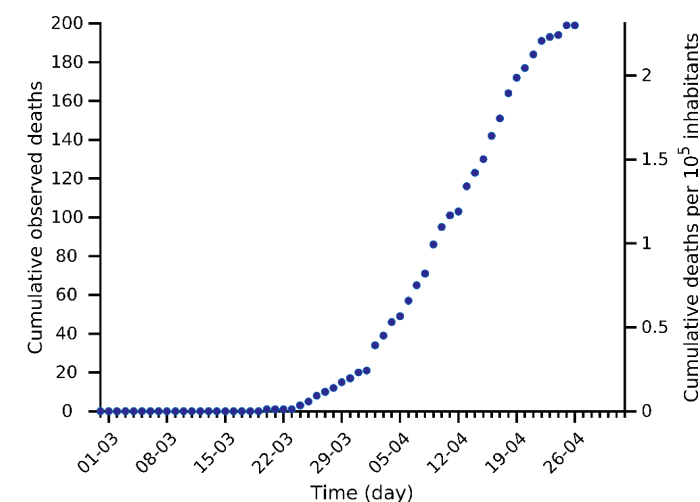
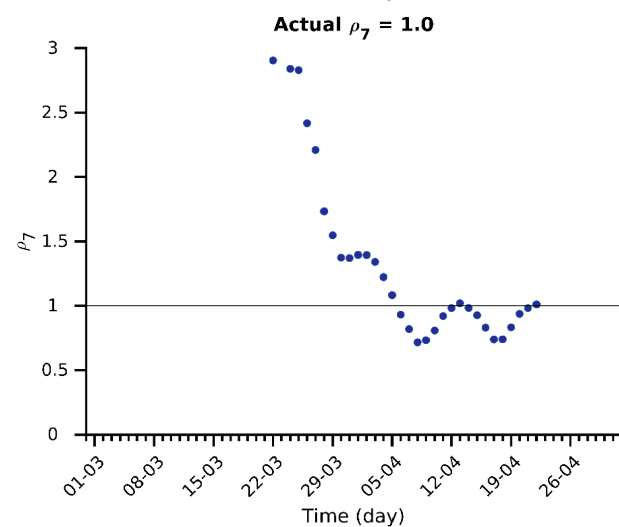
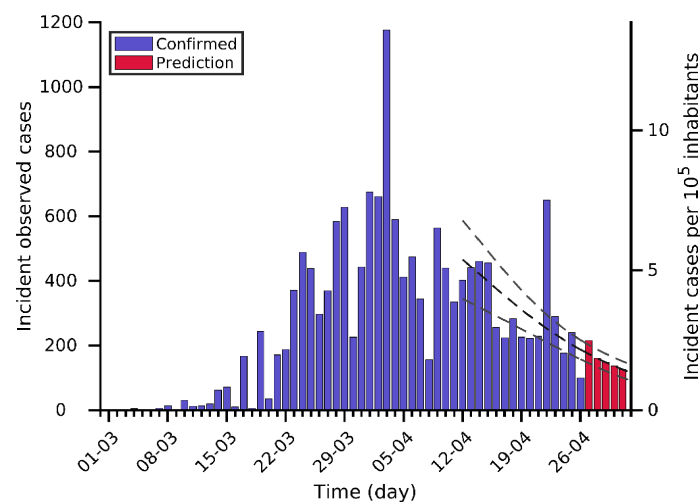
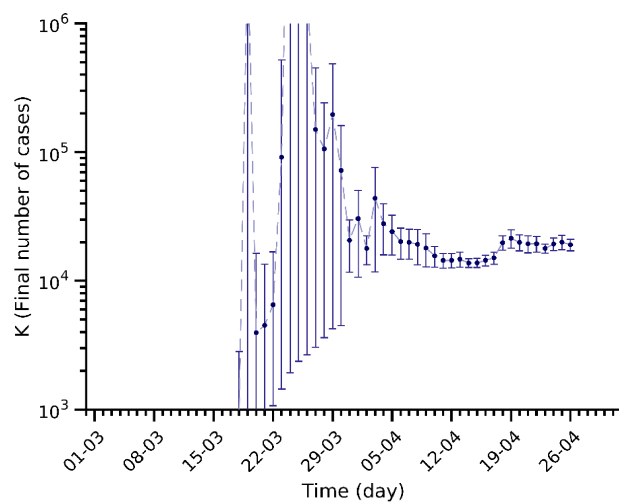
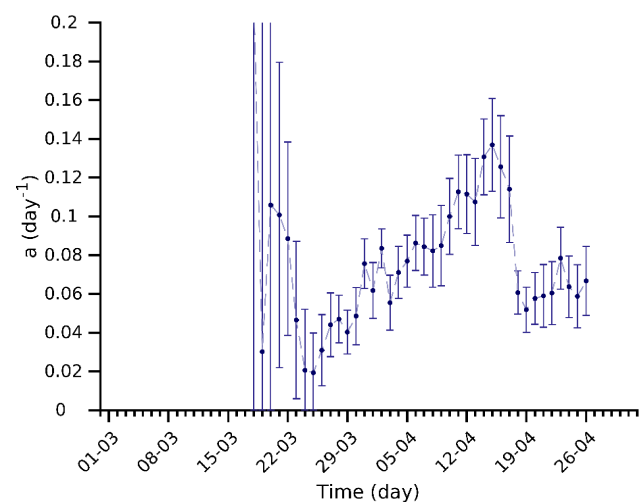
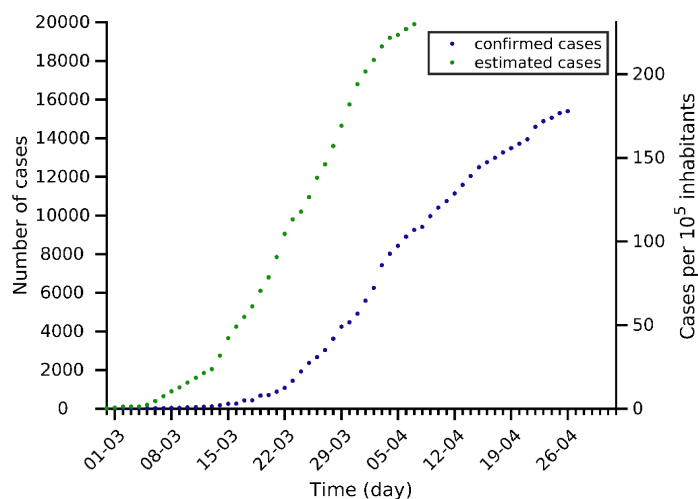
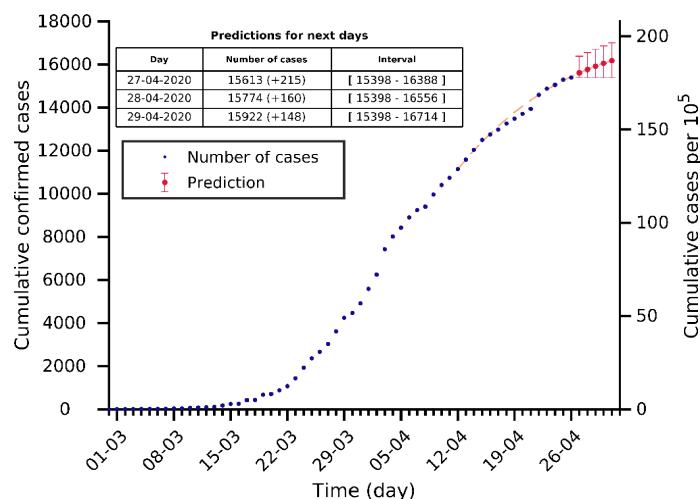


# Ecuador 26-04-2020. Population: 17.6M. Current cumulated incidence: 129/10<sup>5</sup>

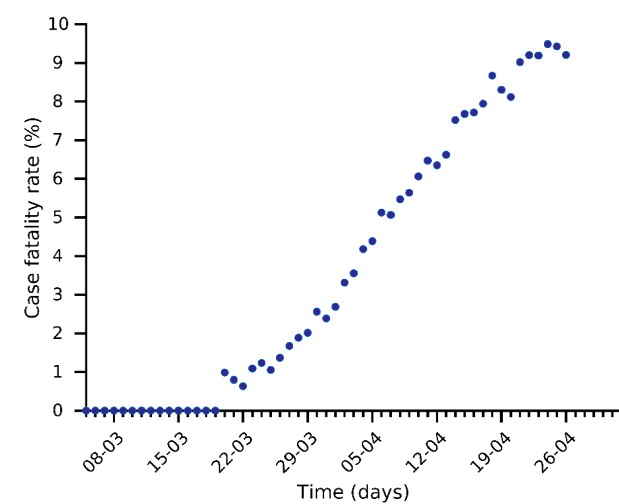
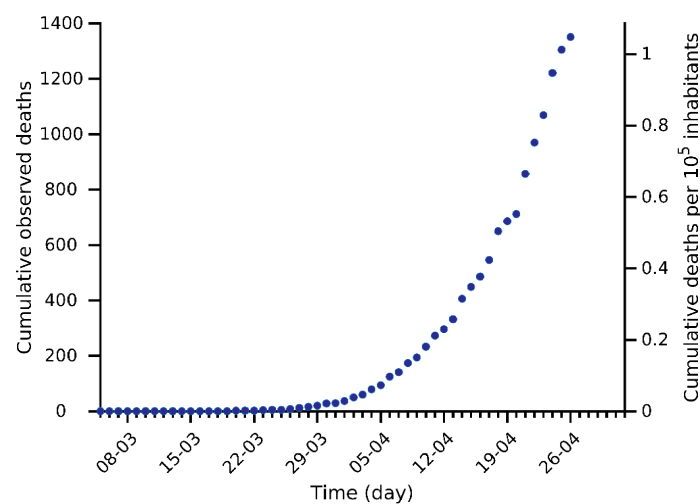
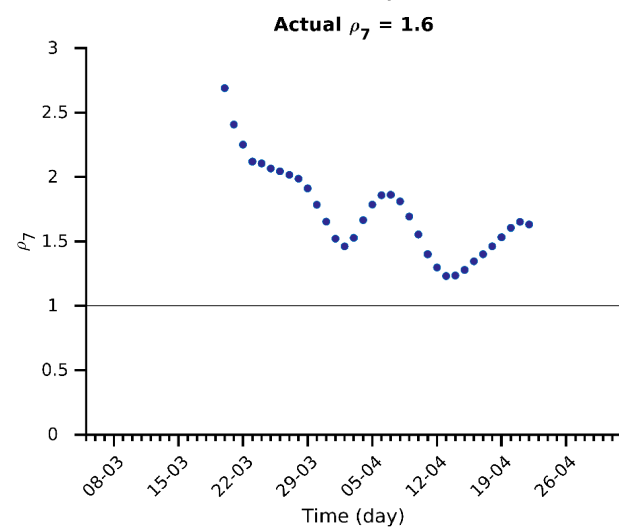
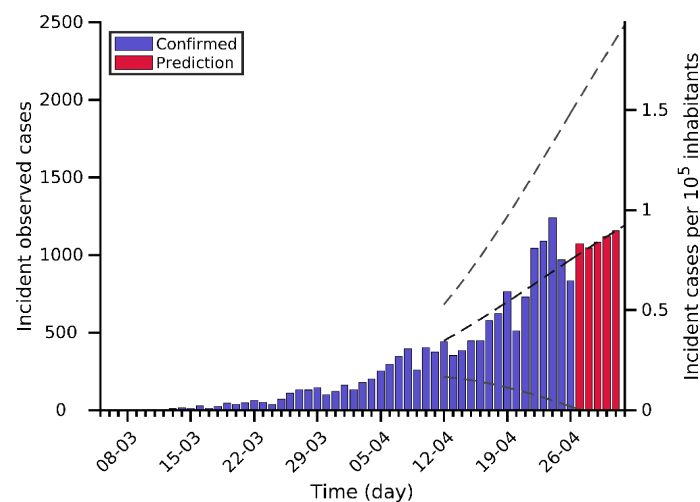
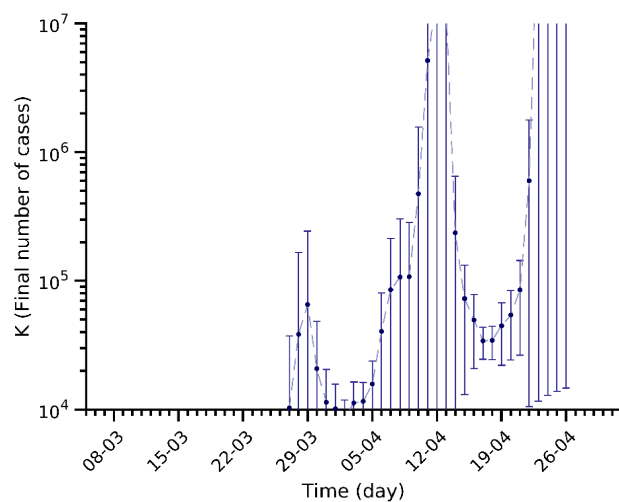
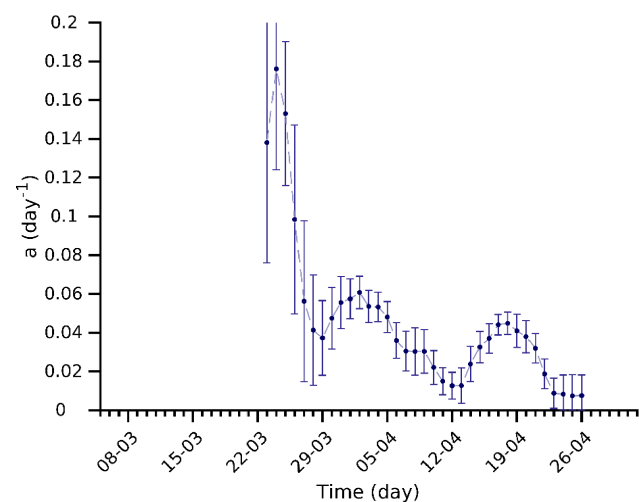
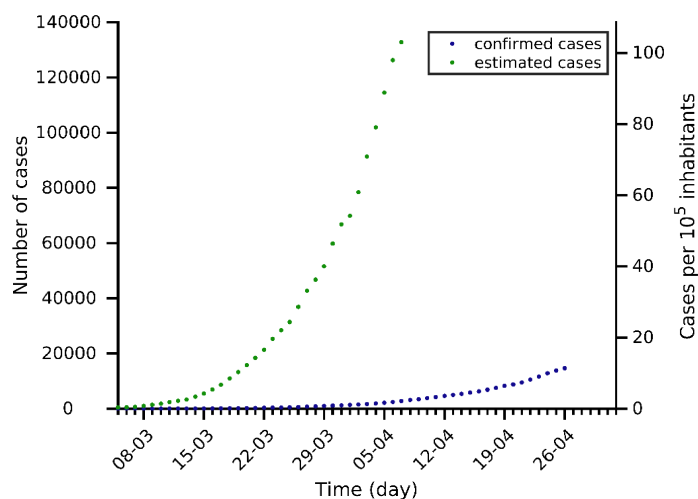
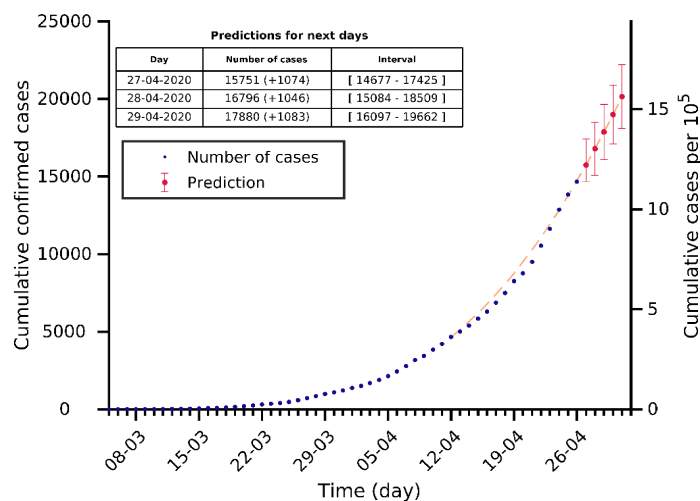




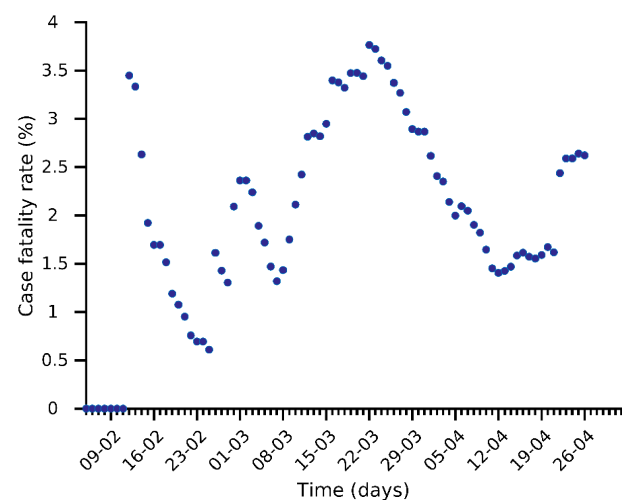
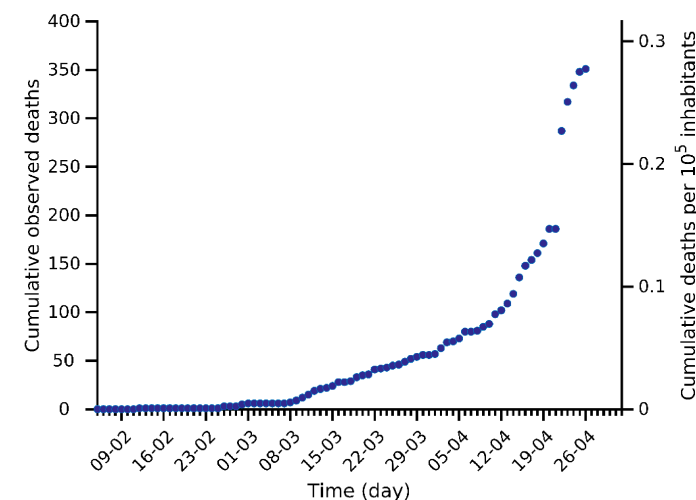
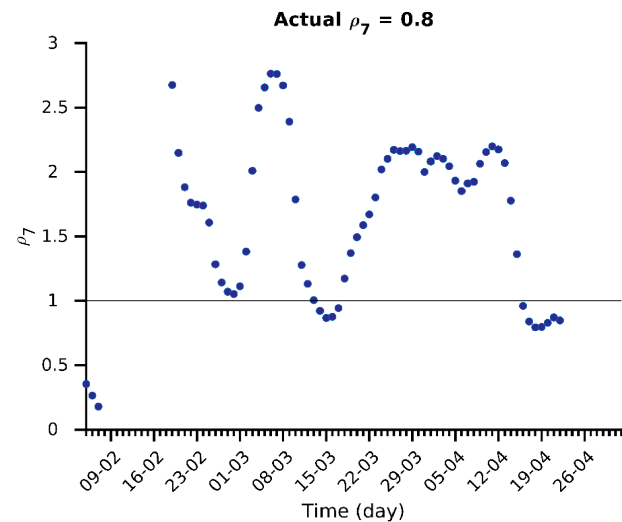
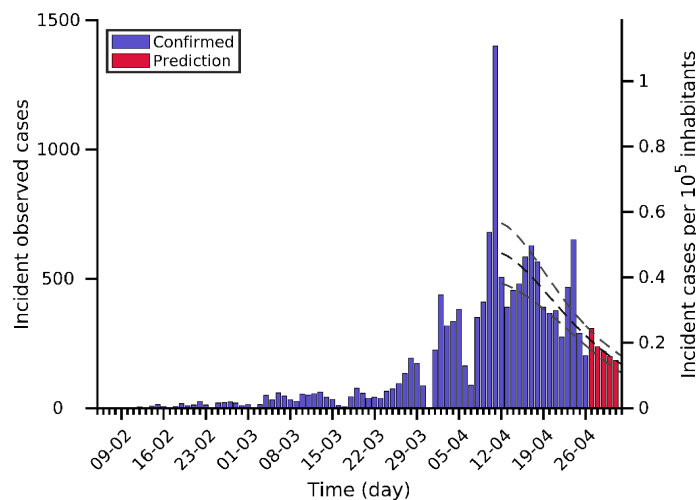
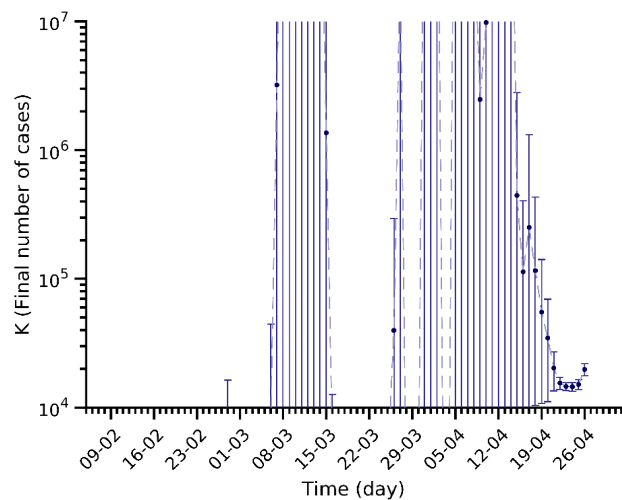
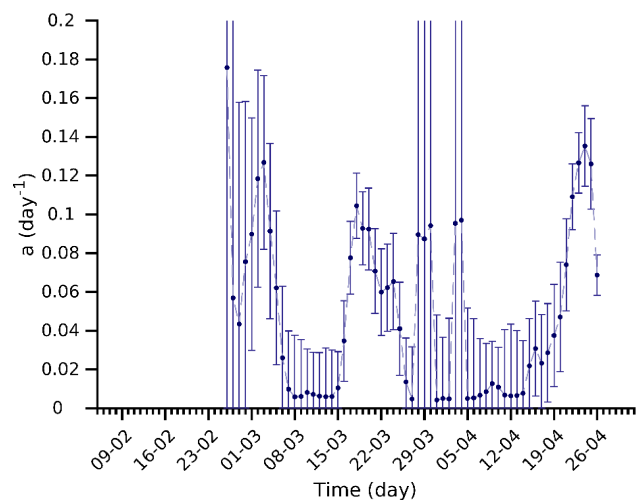
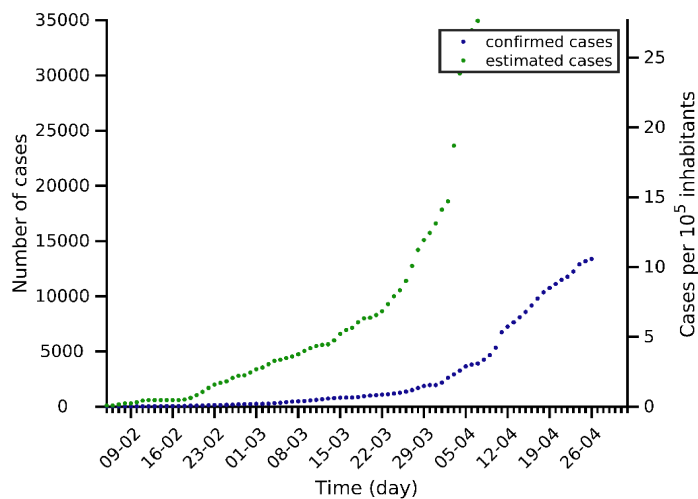
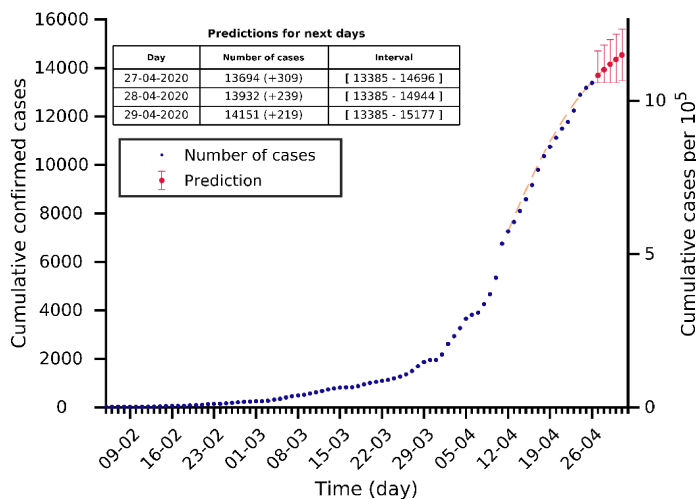
# Israel 26-04-2020. Population: 8.7M. Current cumulated incidence: 178/10<sup>5</sup>



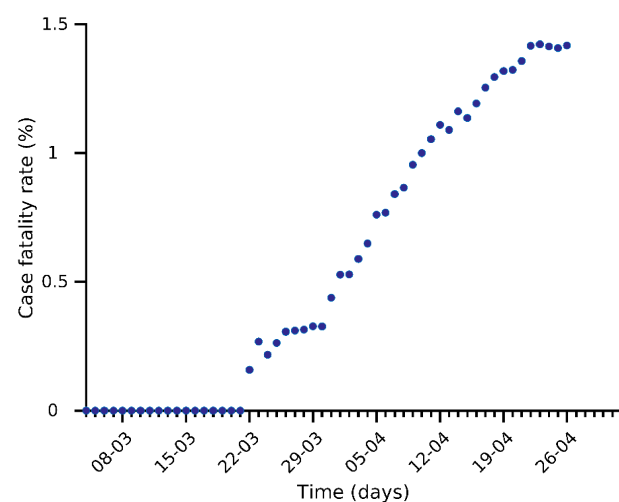
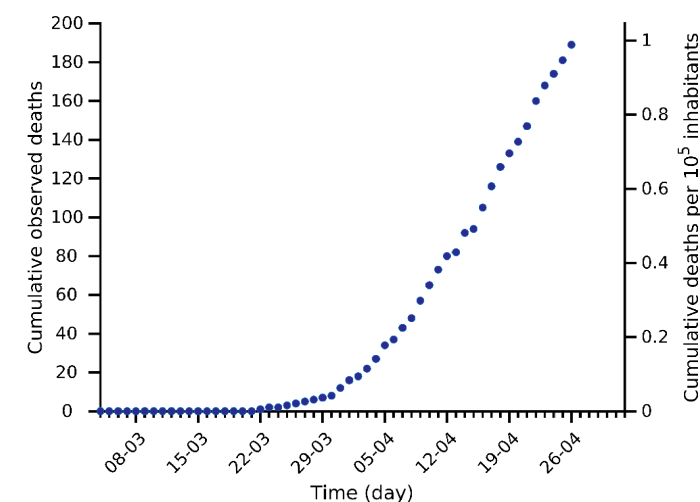
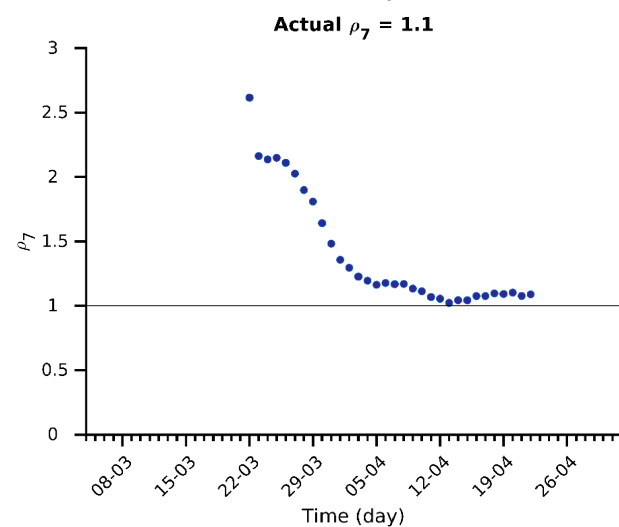
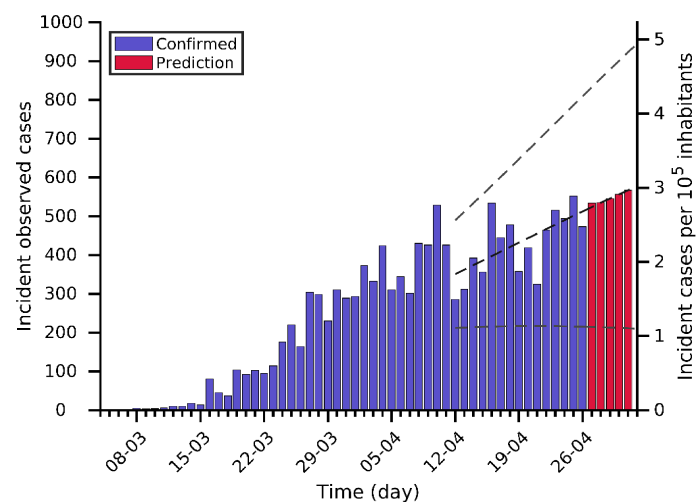
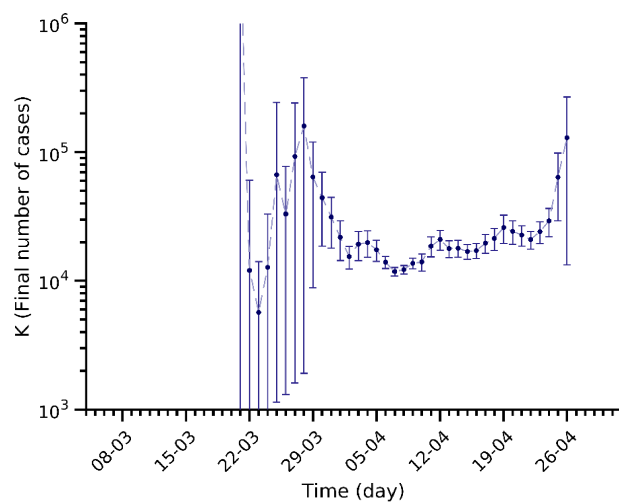
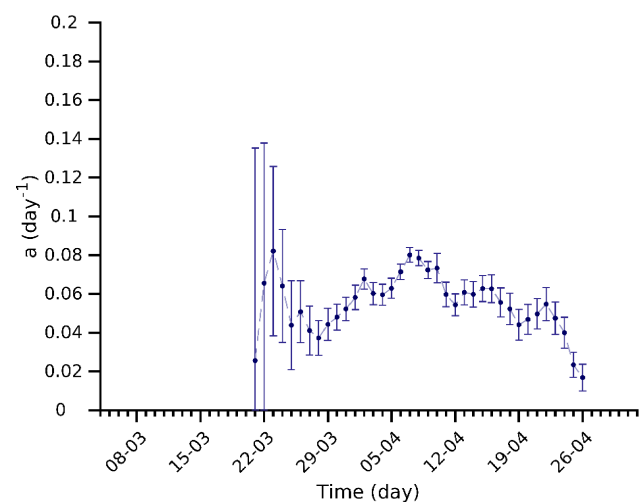
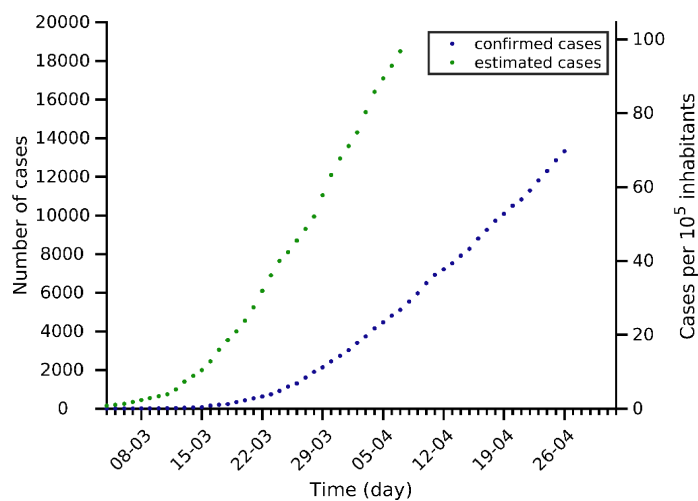
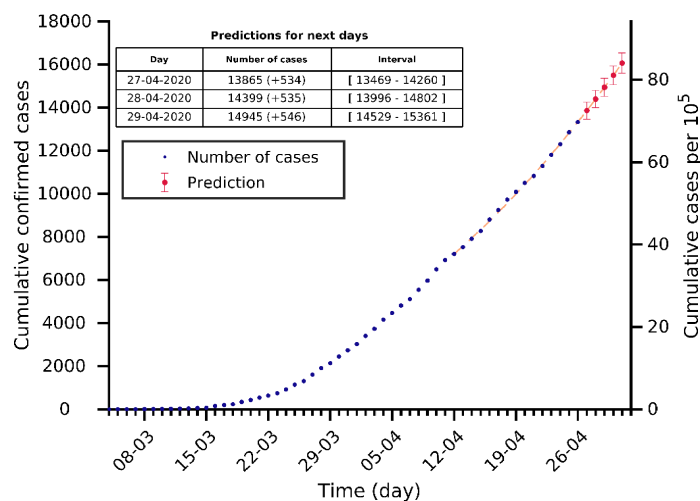
# Mexico 26-04-2020. Population: 128.9M. Current cumulated incidence: 11/10<sup>5</sup>



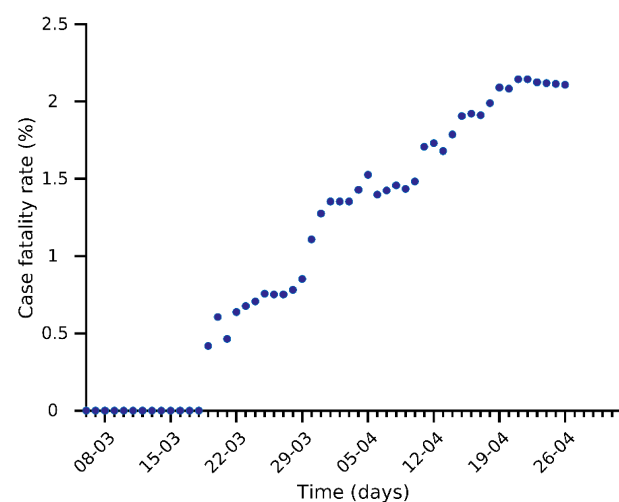
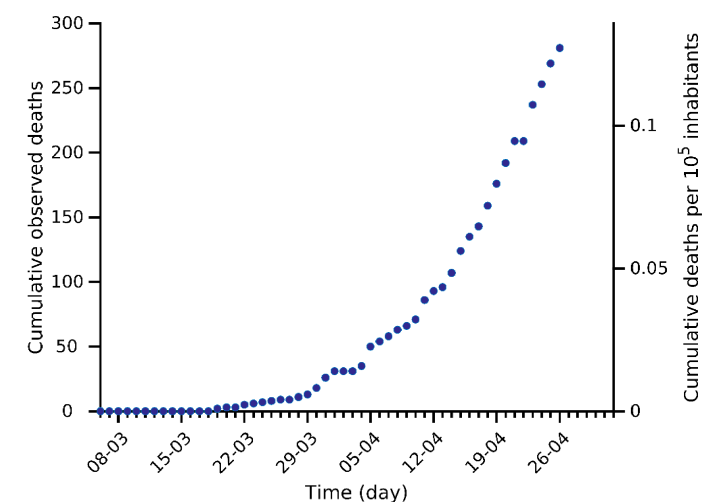
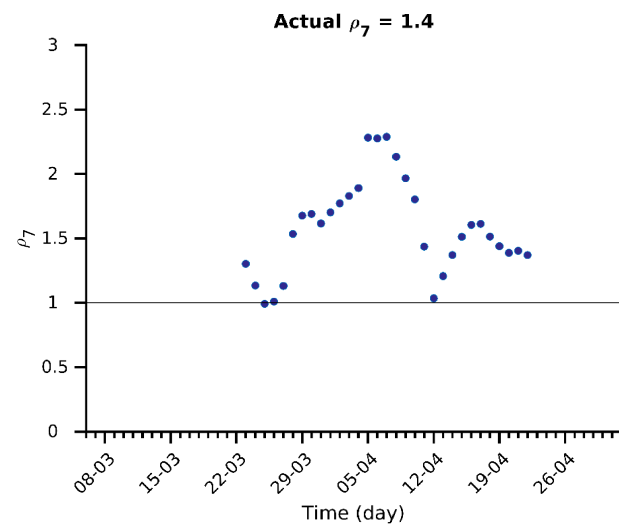
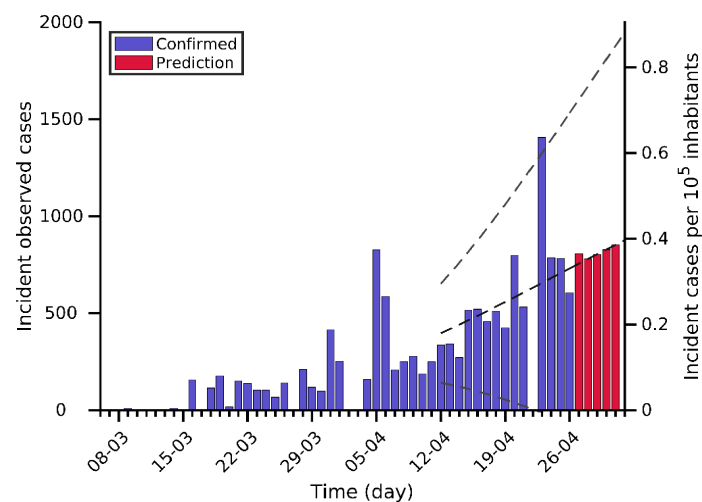
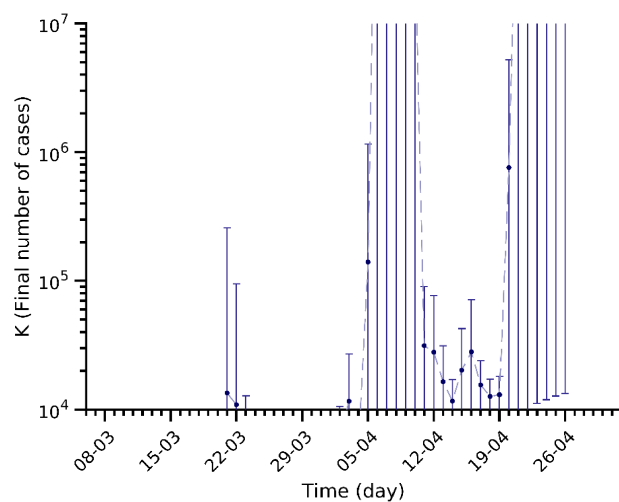
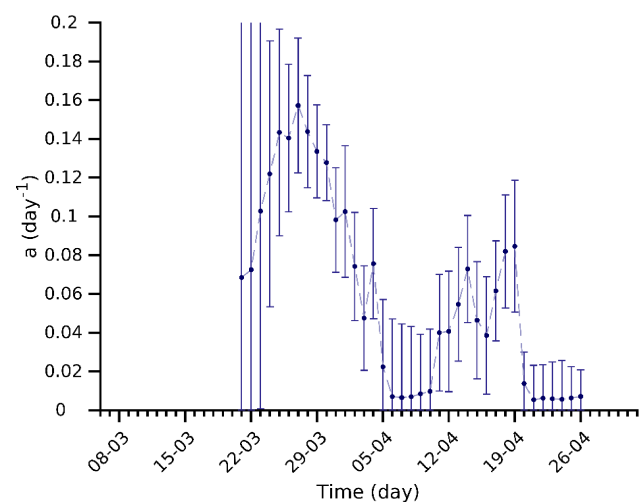
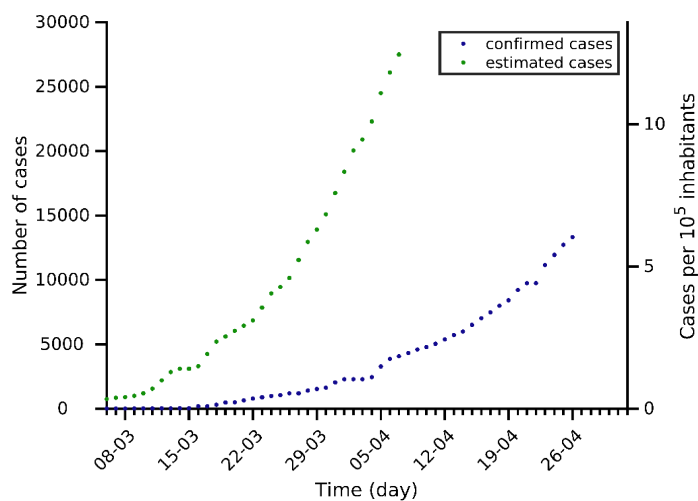
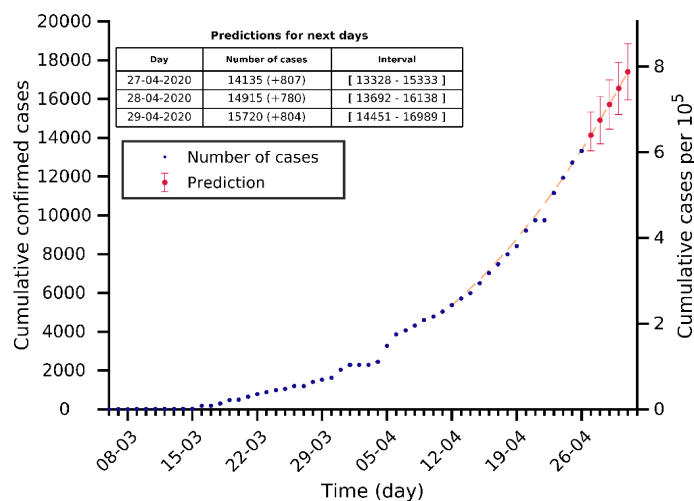
# Japan 26-04-2020. Population: 126.5M. Current cumulated incidence: 11/10<sup>5</sup>



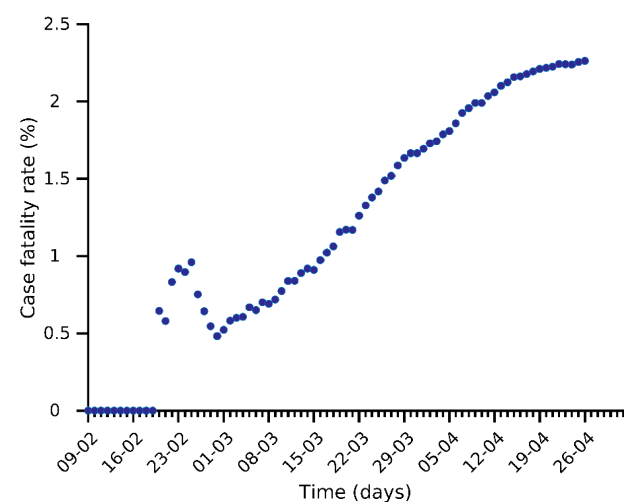
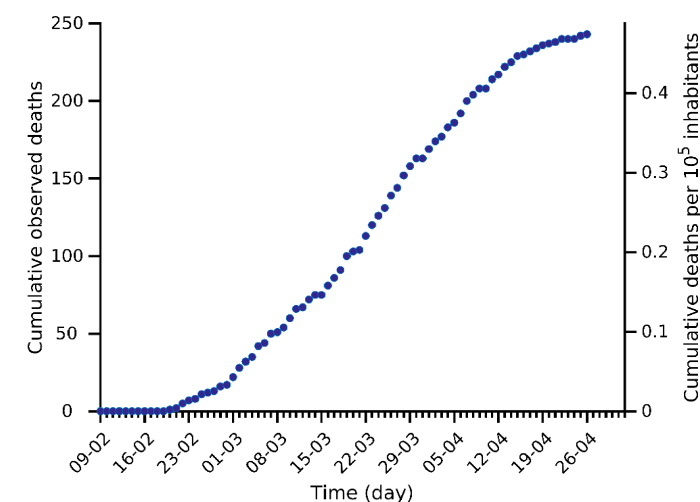
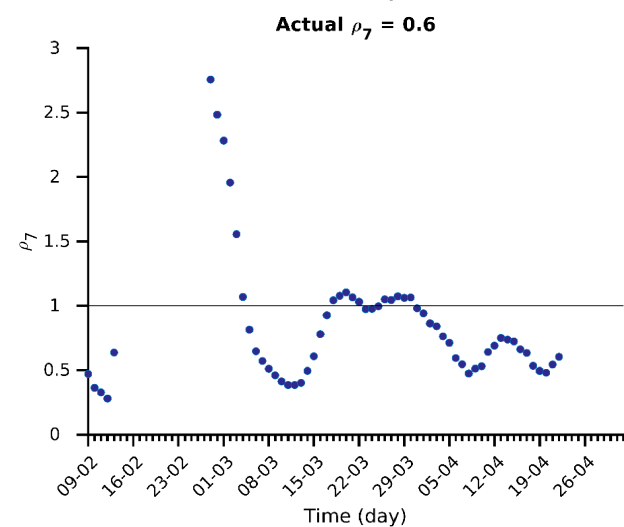
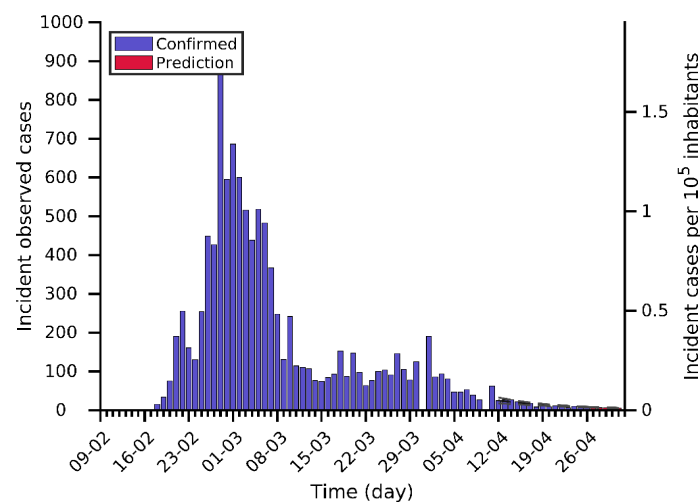
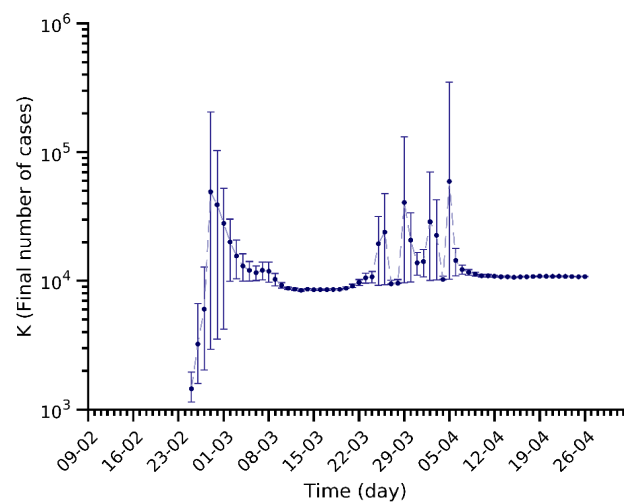
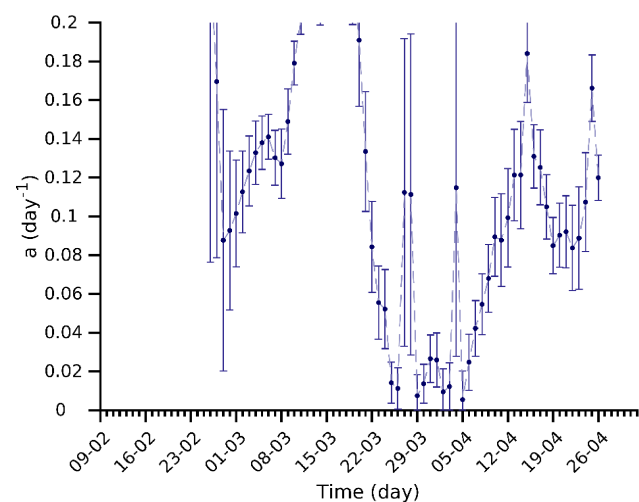
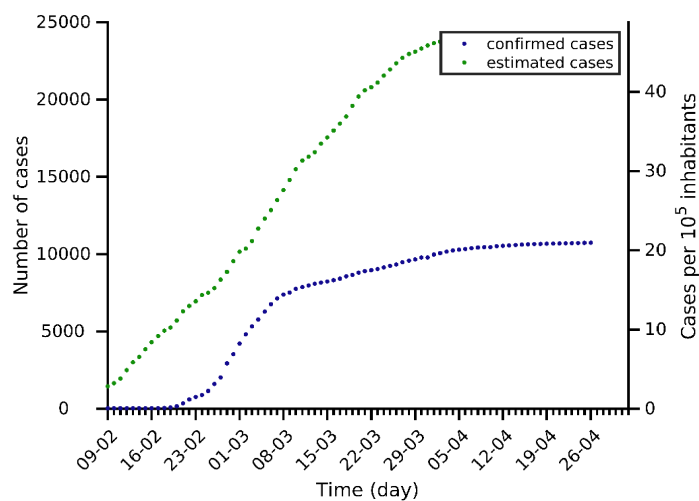
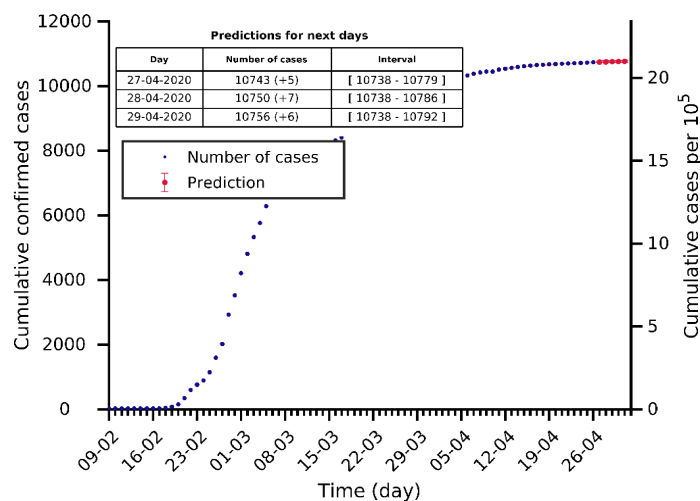
# Chile 26-04-2020. Population: 19.1M. Current cumulated incidence: 70/10<sup>5</sup>



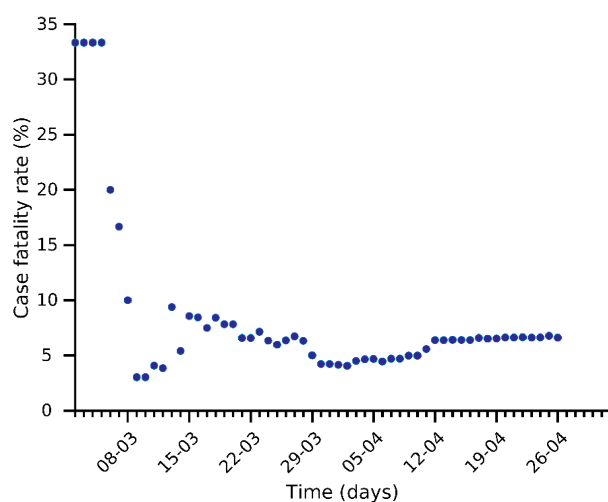
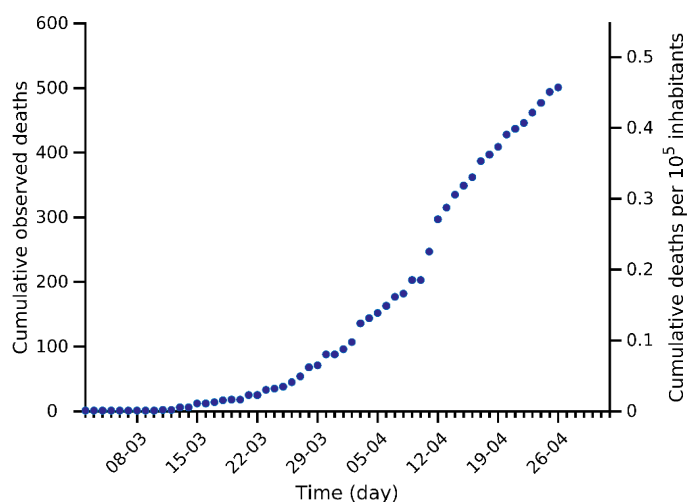
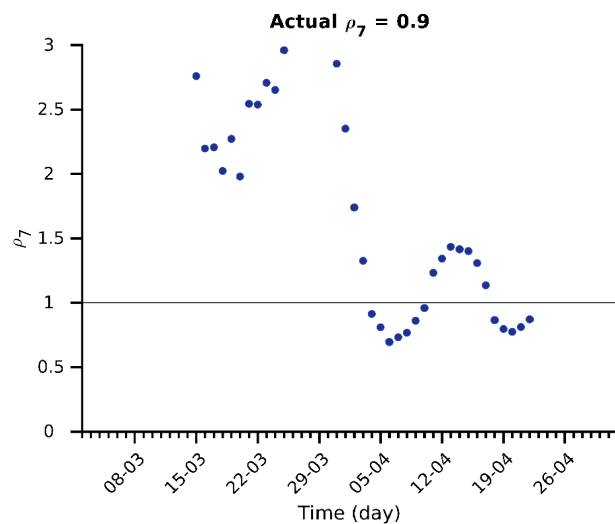
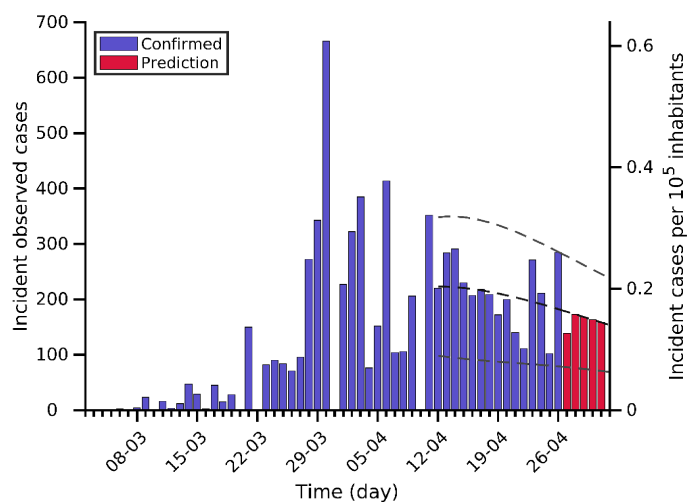
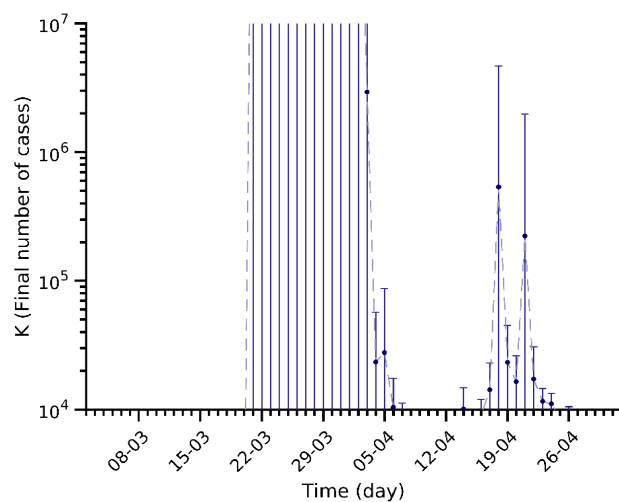
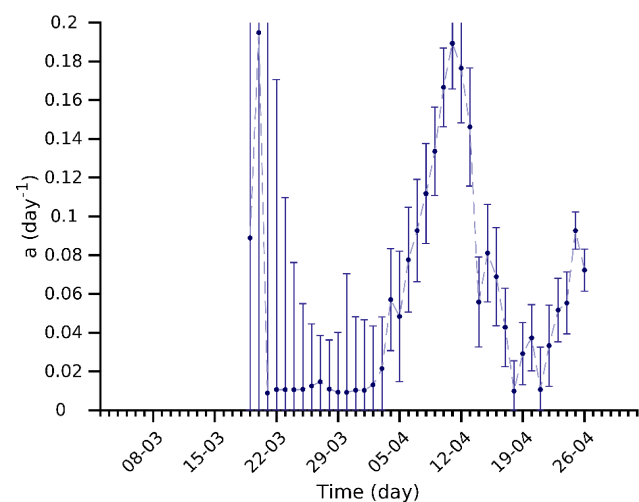
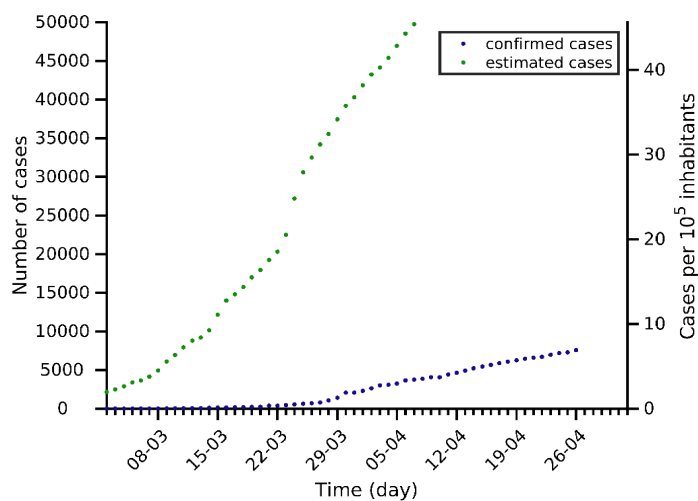
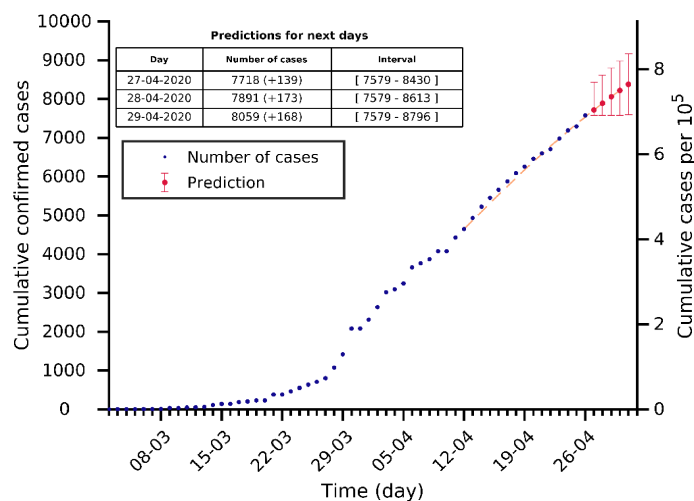
# Pakistan 26-04-2020. Population: 220.9M. Current cumulated incidence: $6/10^5$



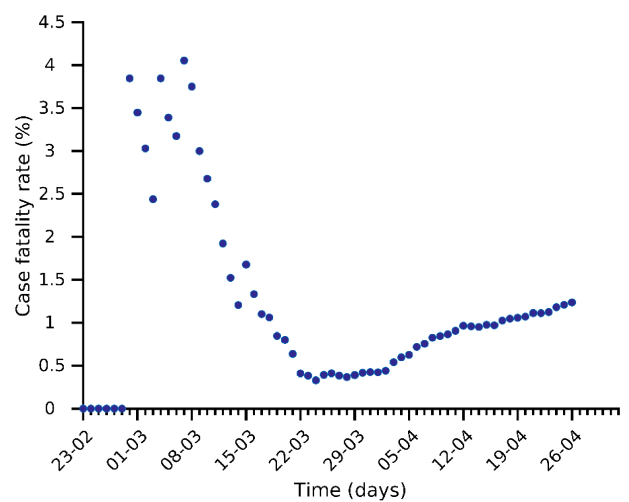
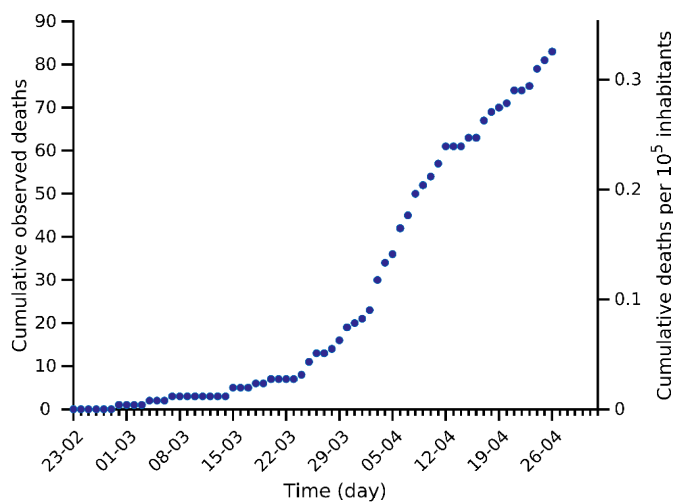
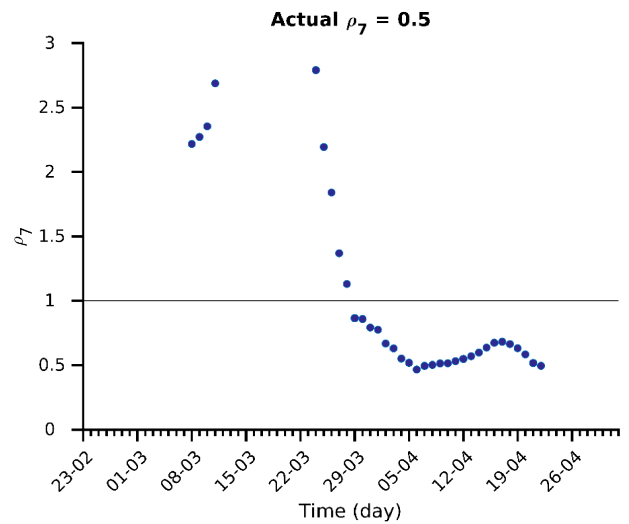
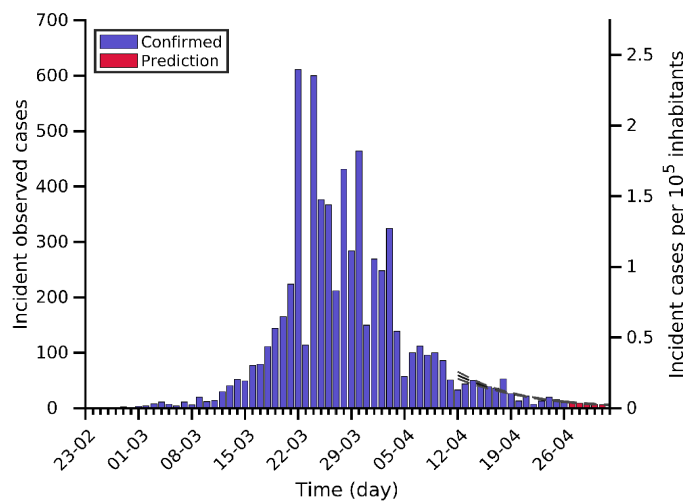
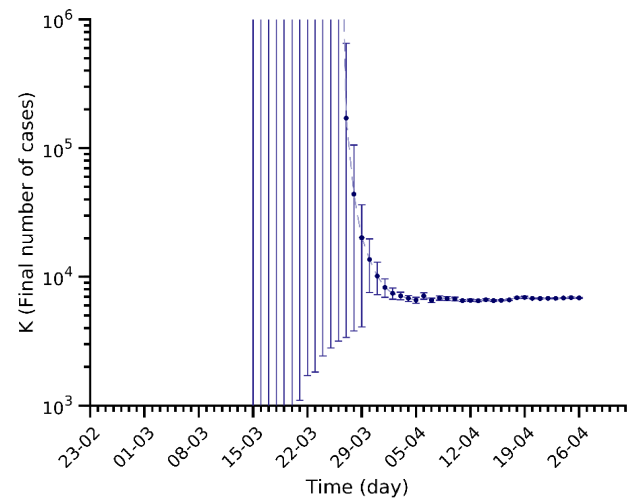
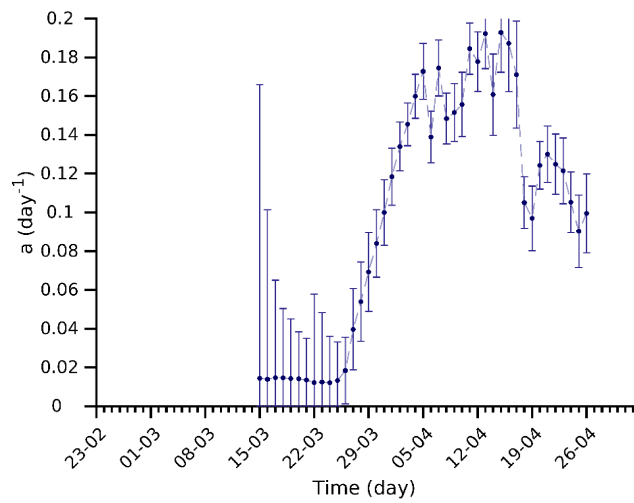
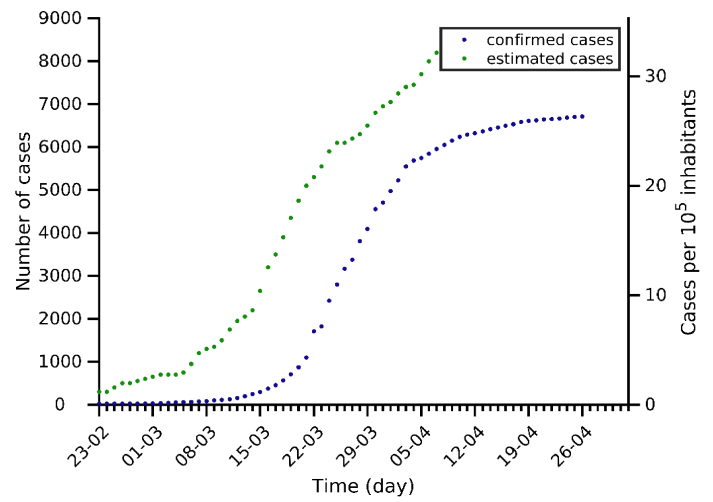
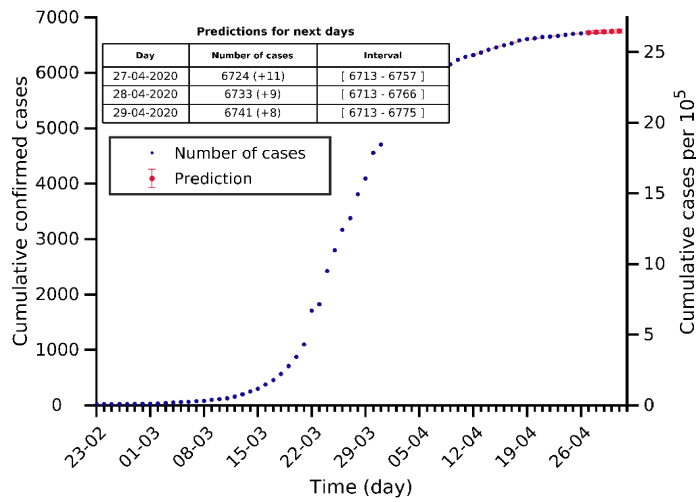
# South Korea 26-04-2020. Population: 51.3M. Current cumulated incidence: 21/10<sup>5</sup>



# Philippines 26-04-2020. Population: 109.6M. Current cumulated incidence: 7/10<sup>5</sup>

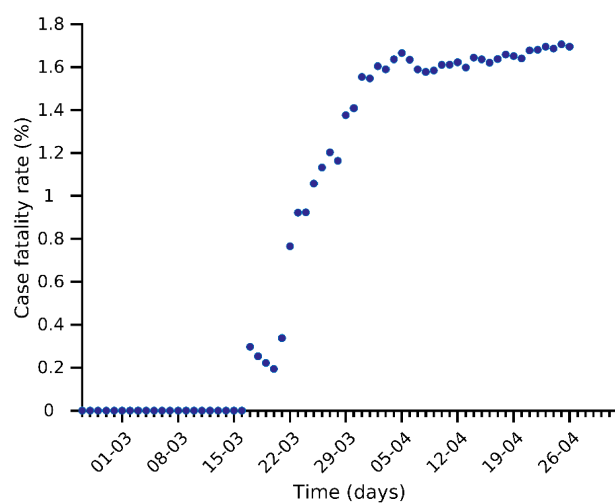
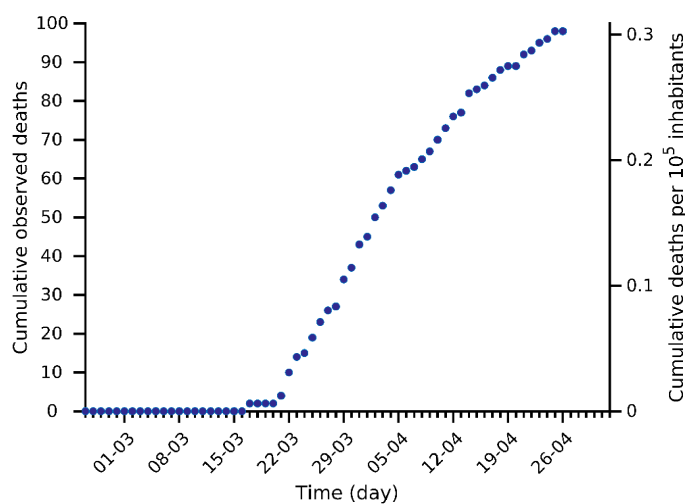
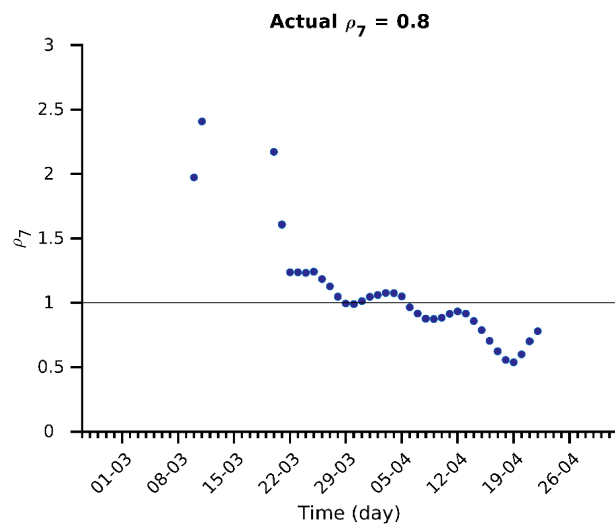
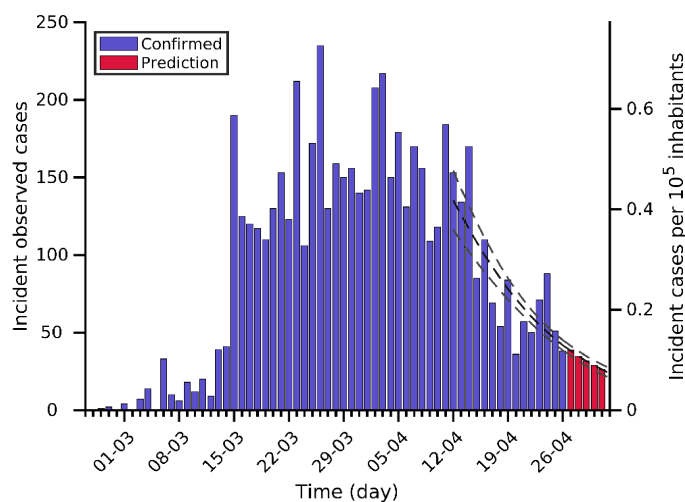
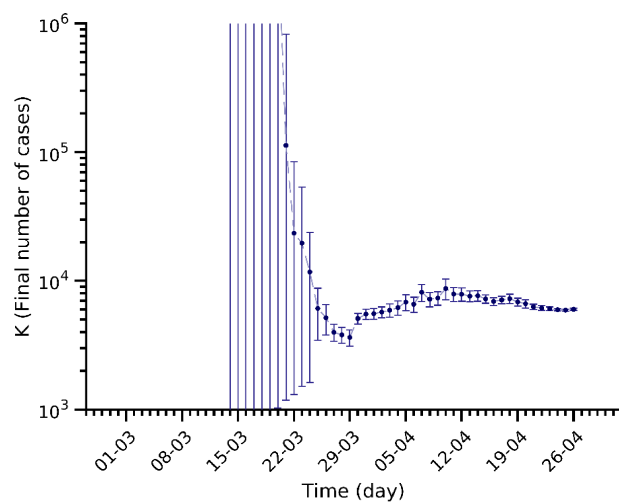
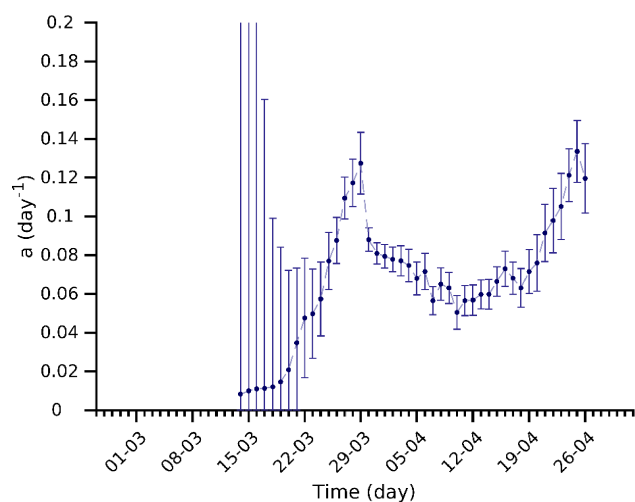
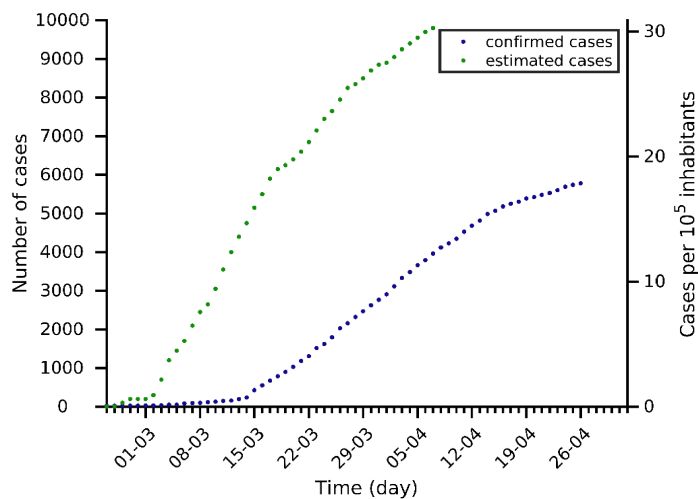
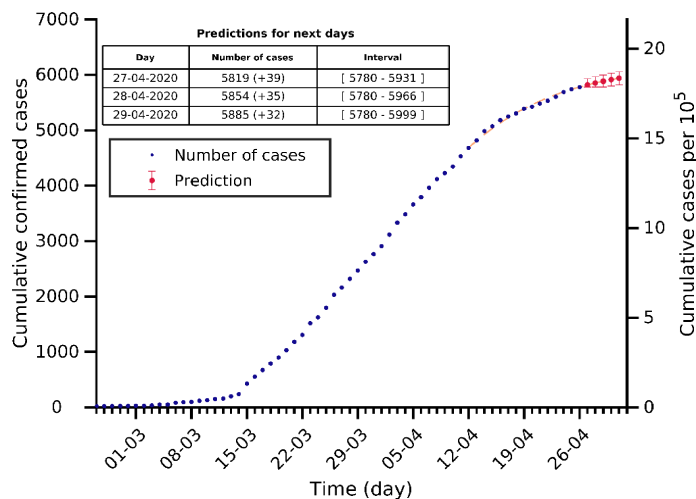


# Australia 26-04-2020. Population: 25.5M. Current cumulated incidence: $26/10^5$

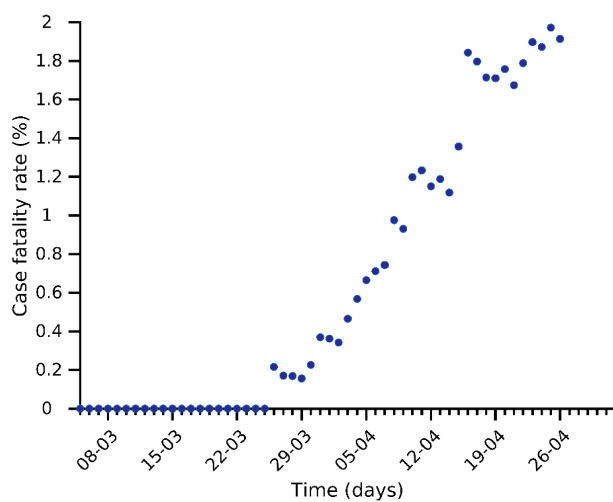
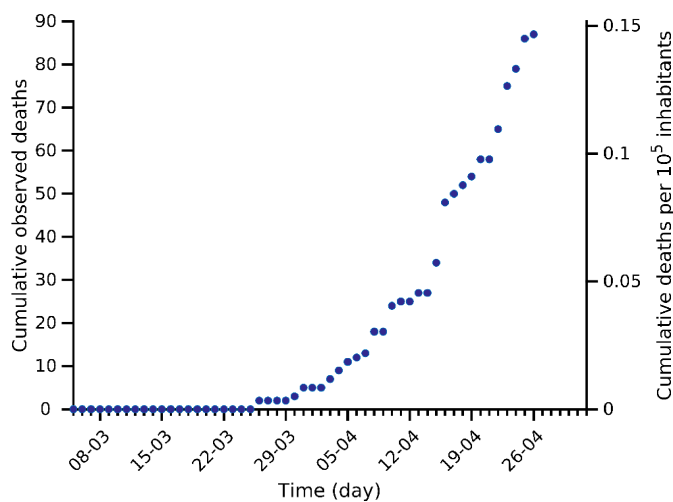
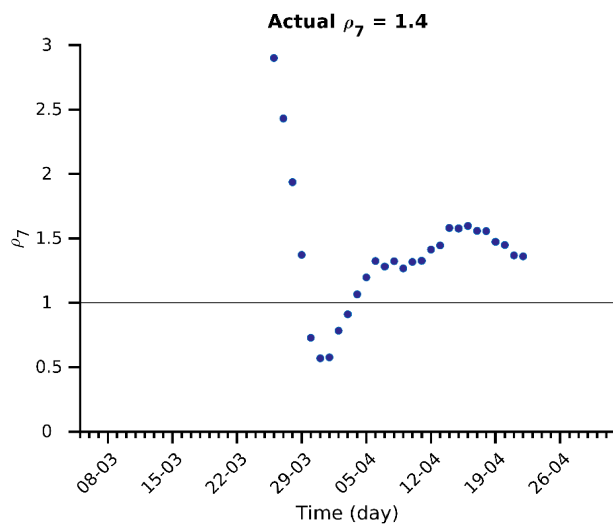
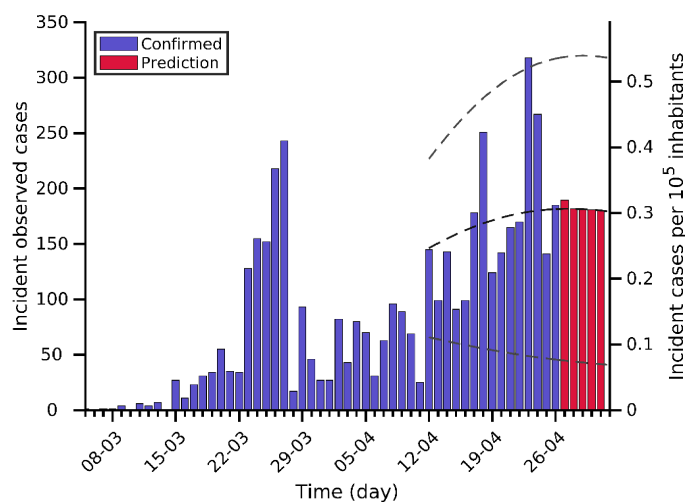
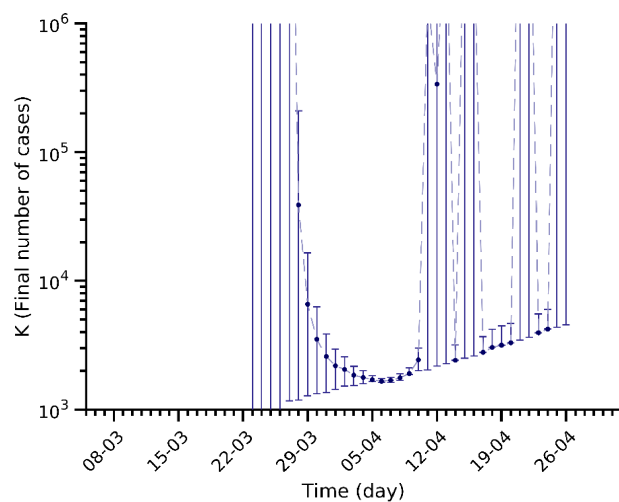
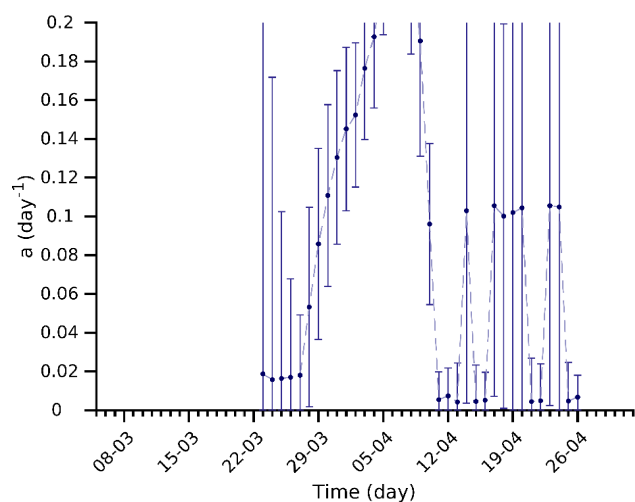
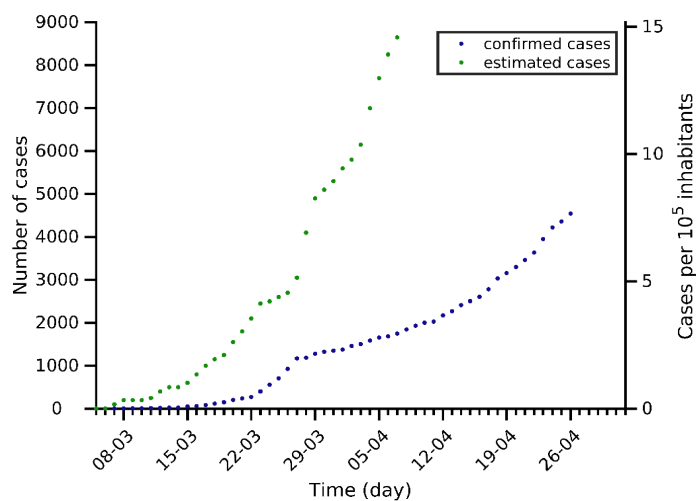
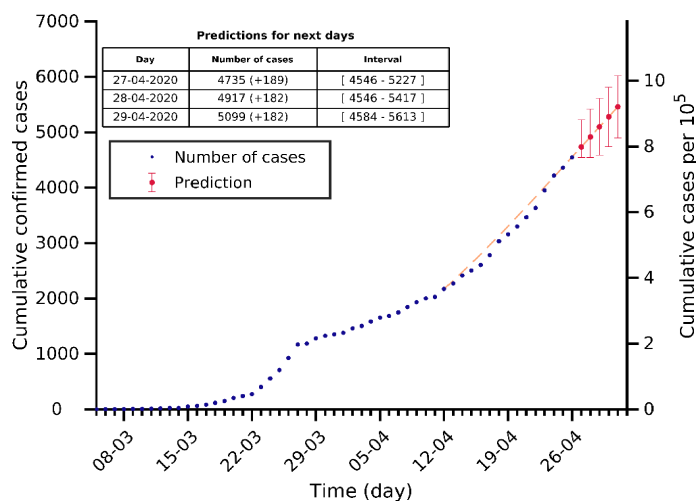




# Malaysia 26-04-2020. Population: 32.4M. Current cumulated incidence: 18/10<sup>5</sup>



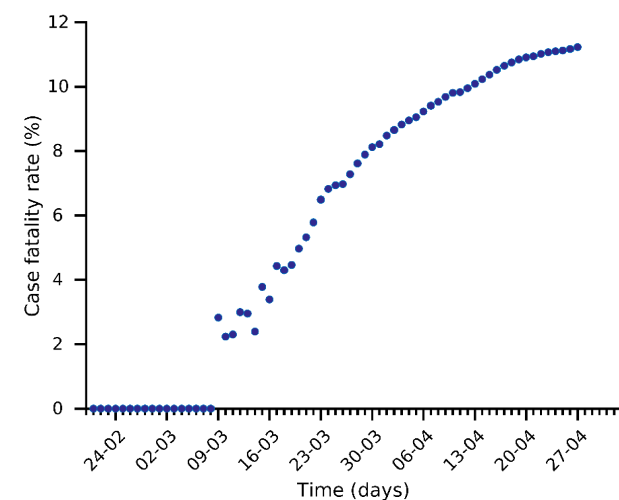
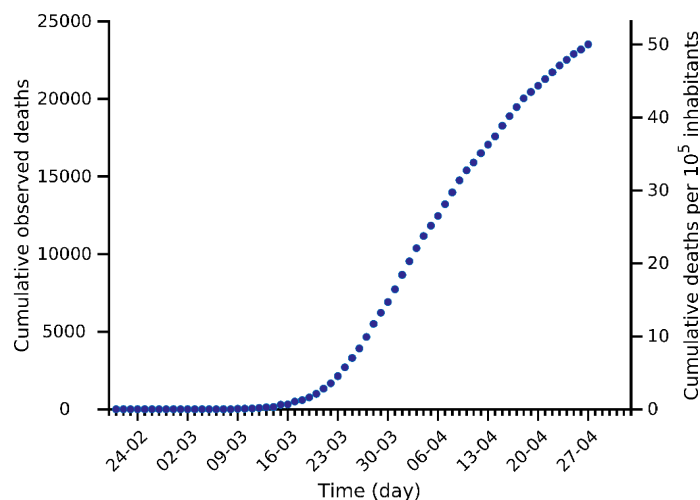
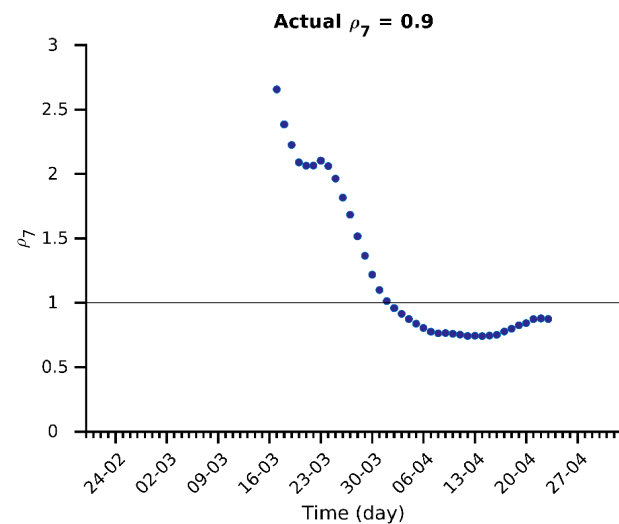
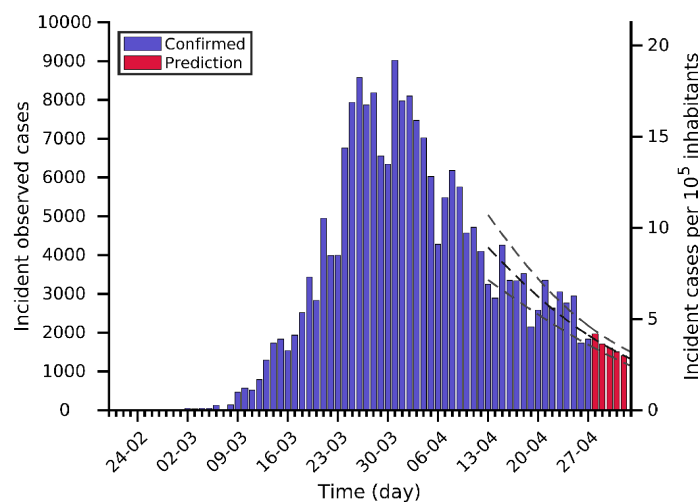
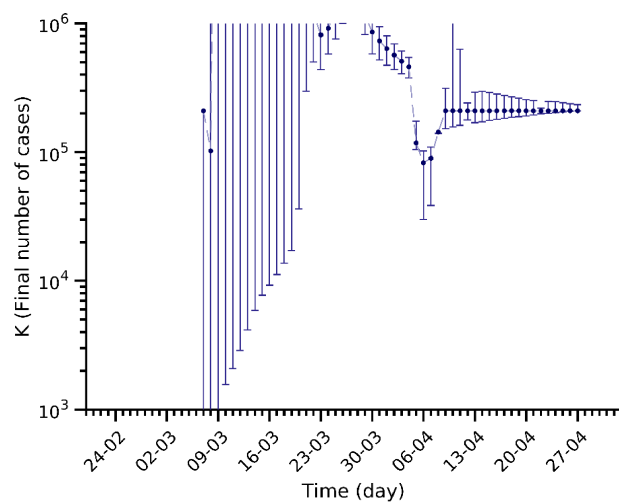
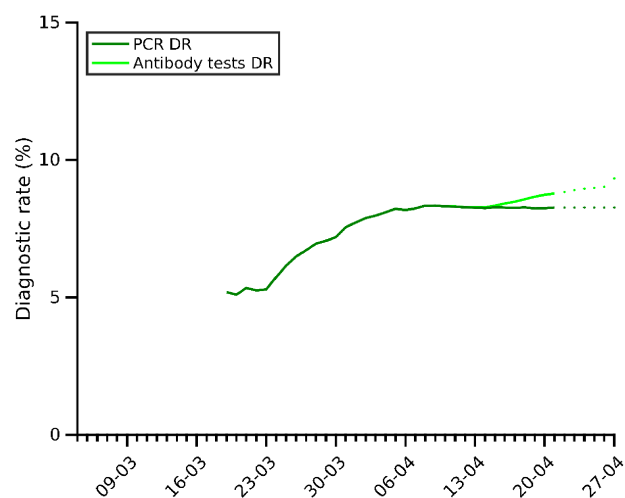
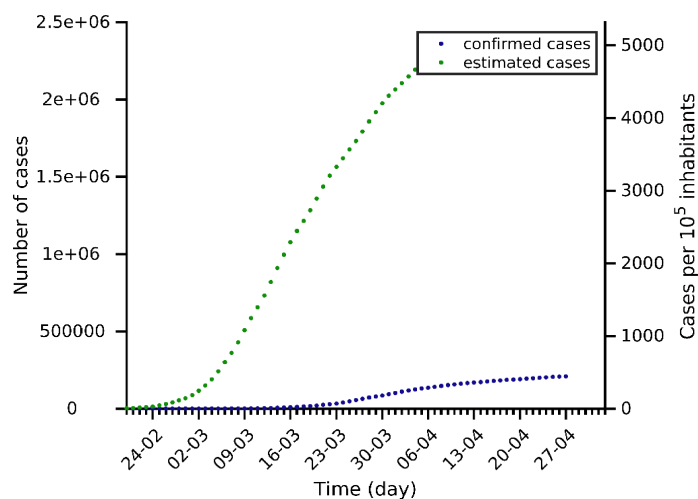
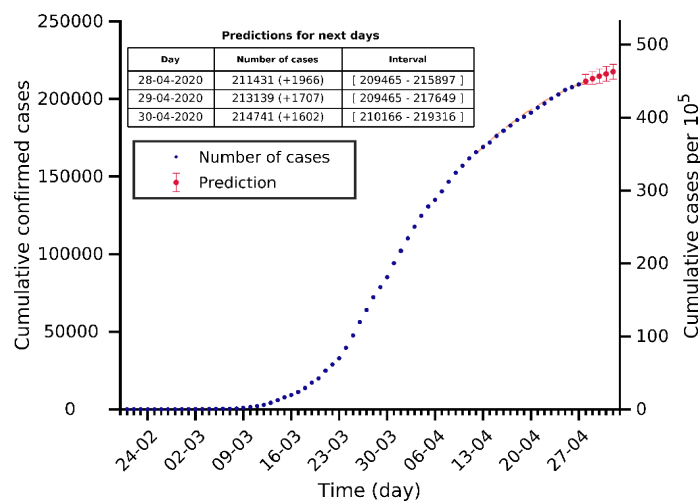
# South Africa 26-04-2020. Population: 59.3M. Current cumulated incidence: 8/10<sup>5</sup>



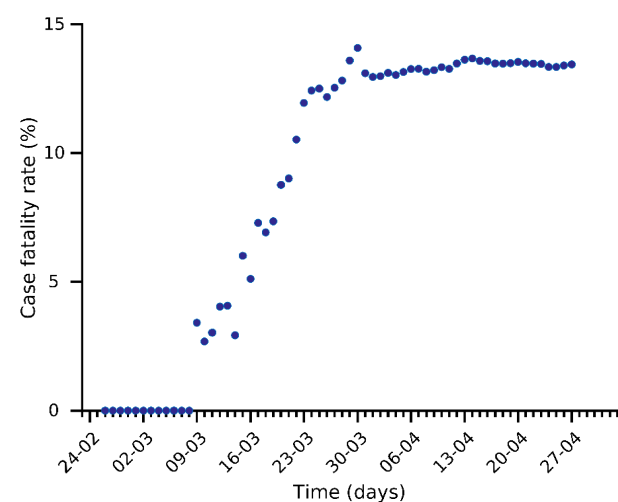
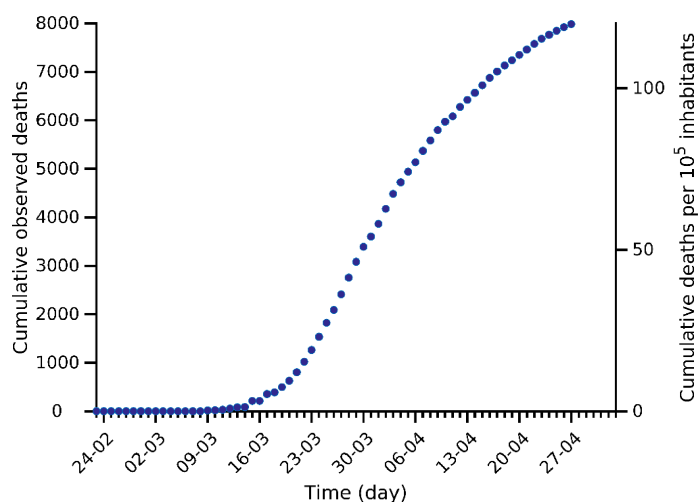
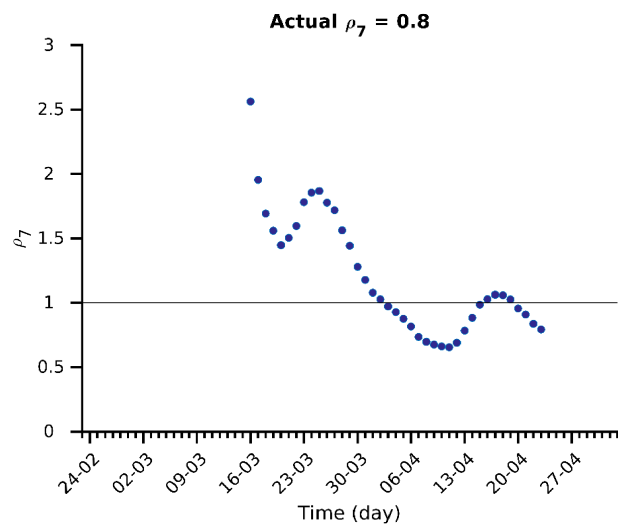
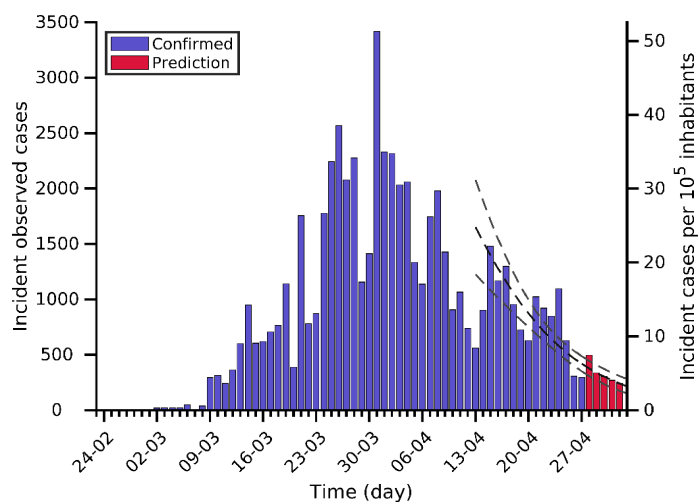
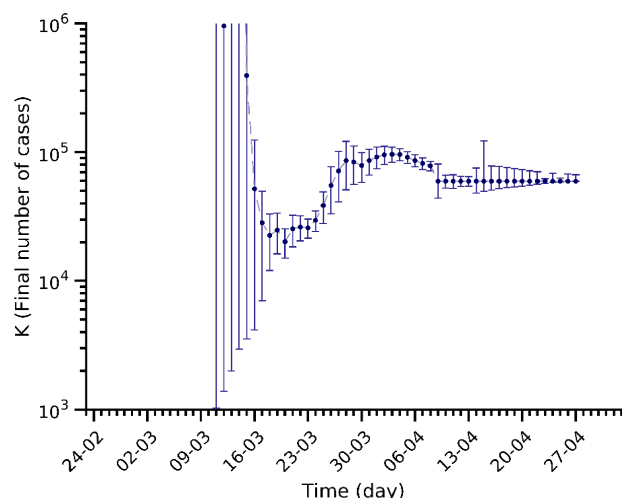
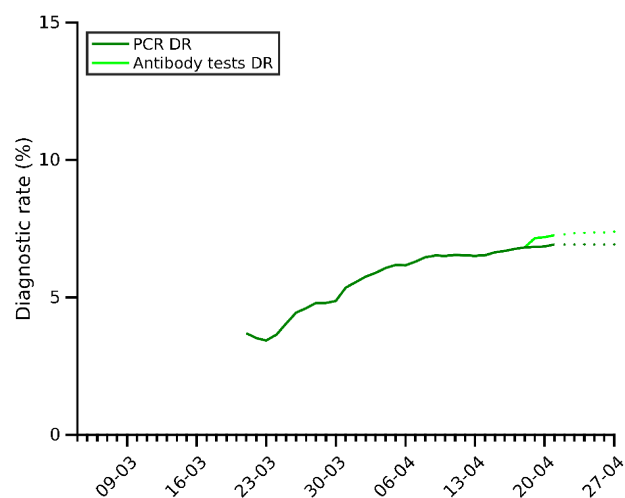
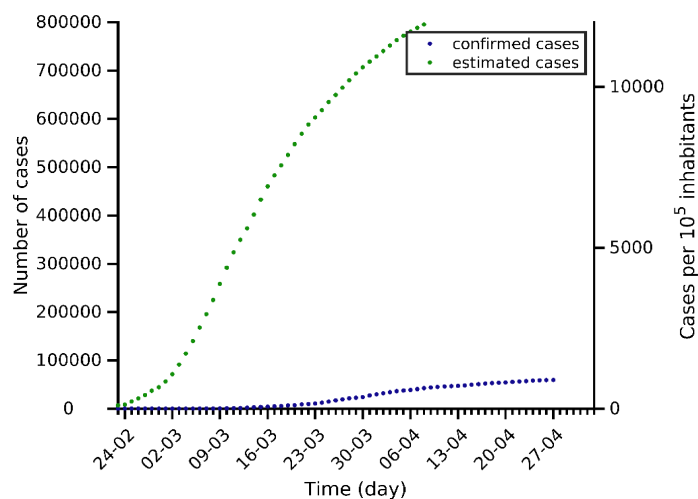
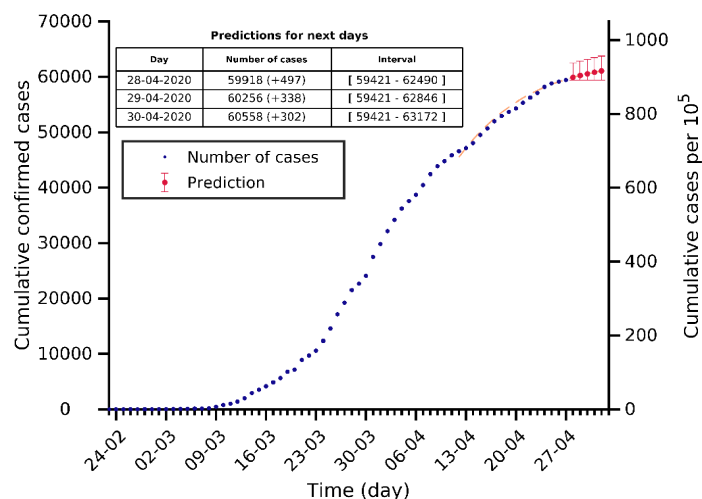
### **(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities**

Data obtained from <https://github.com/datadista/datasets/tree/master/COVID%2019> and  
<https://covid19.isciii.es/>

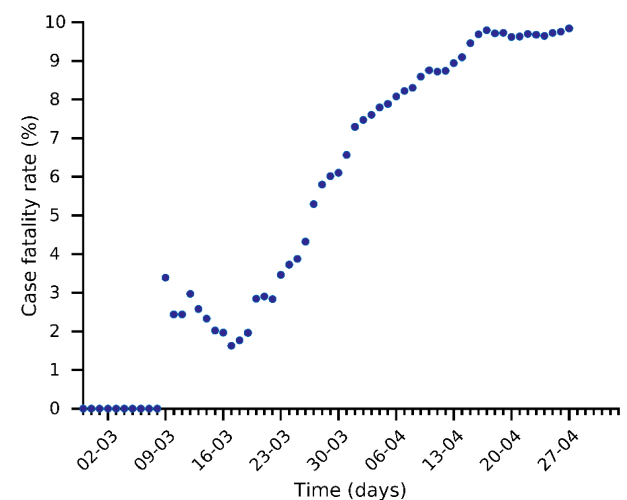
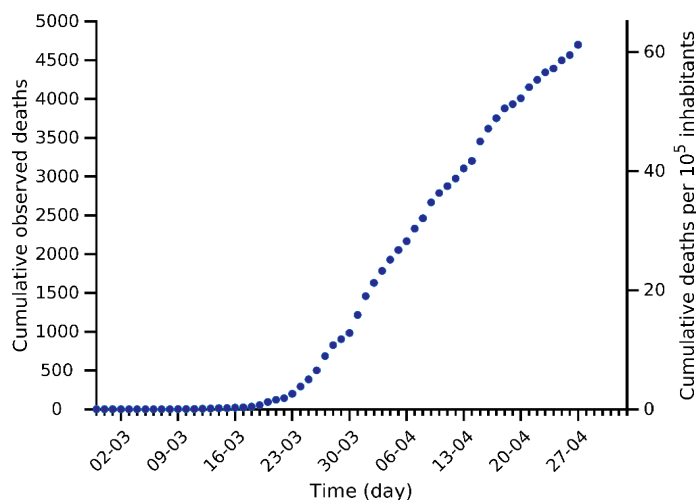
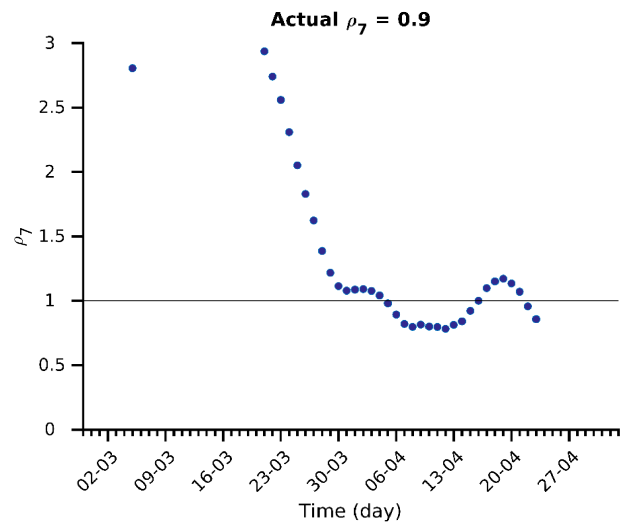
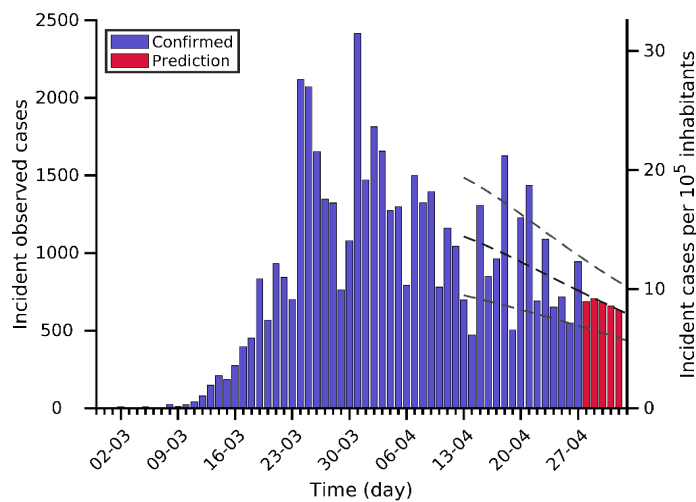
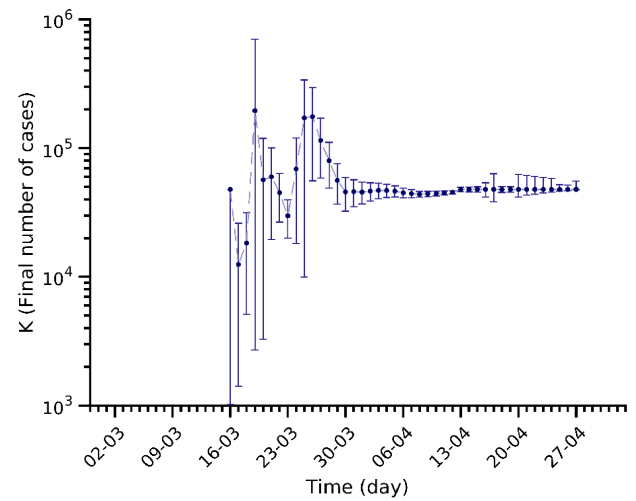
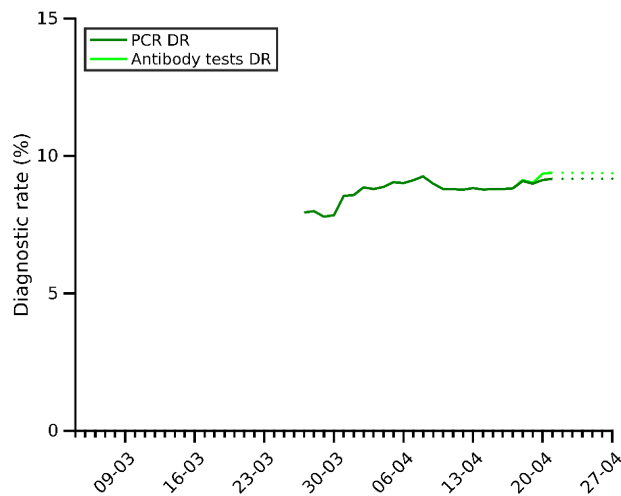
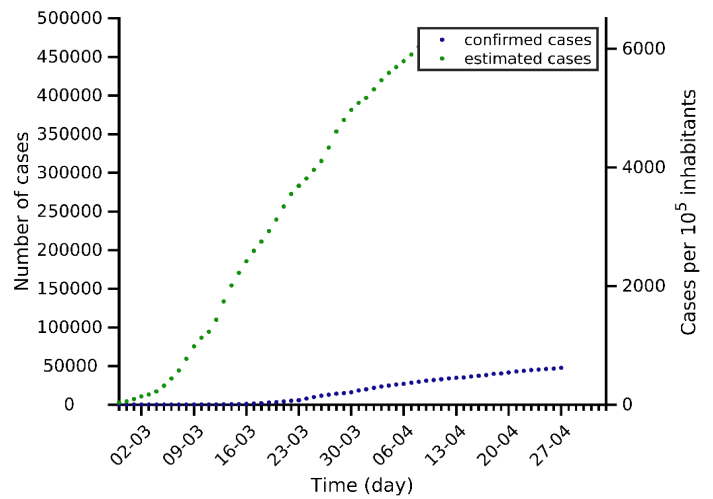
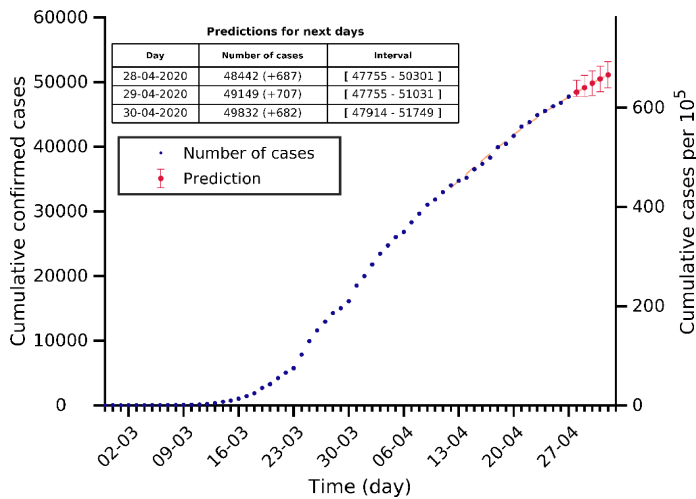
# Spain 27-04-2020. Population: 47.0M. Current cumulated incidence: 445/10<sup>5</sup>



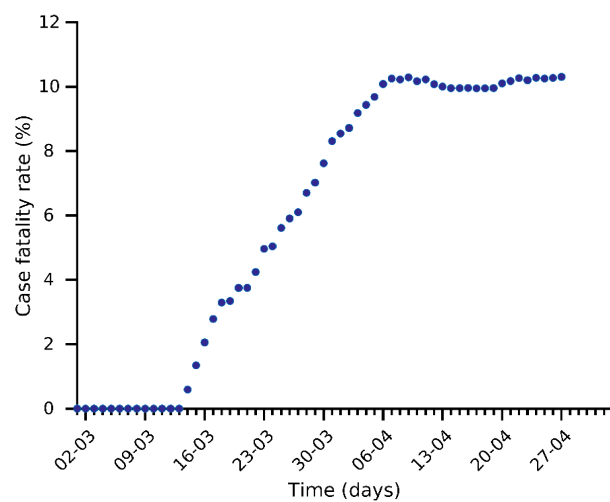
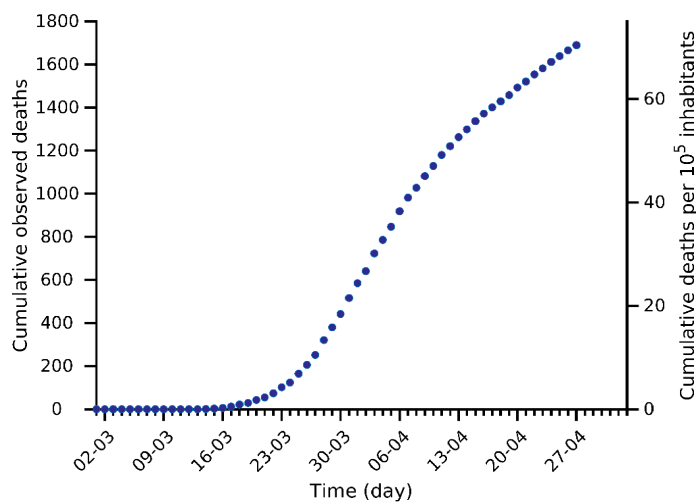
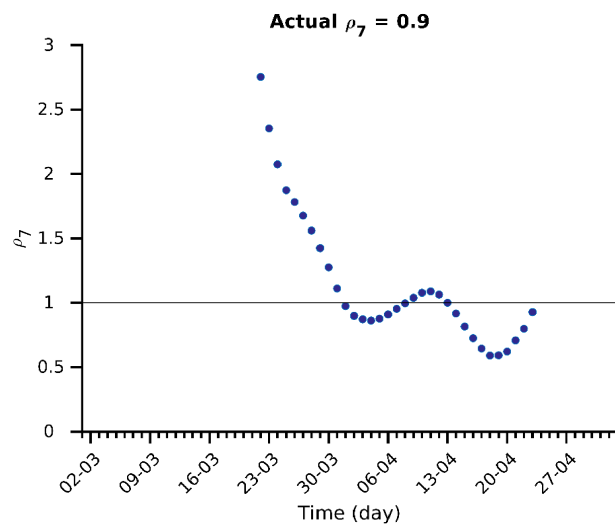
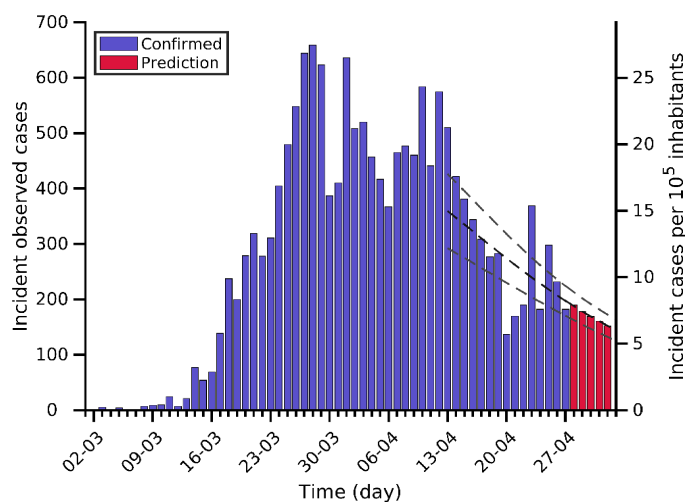
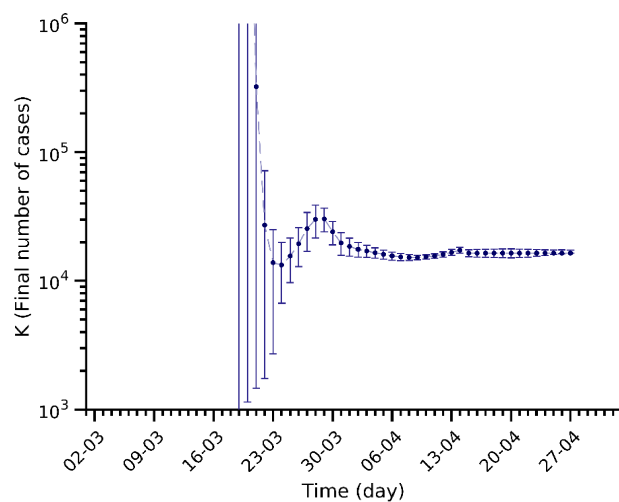
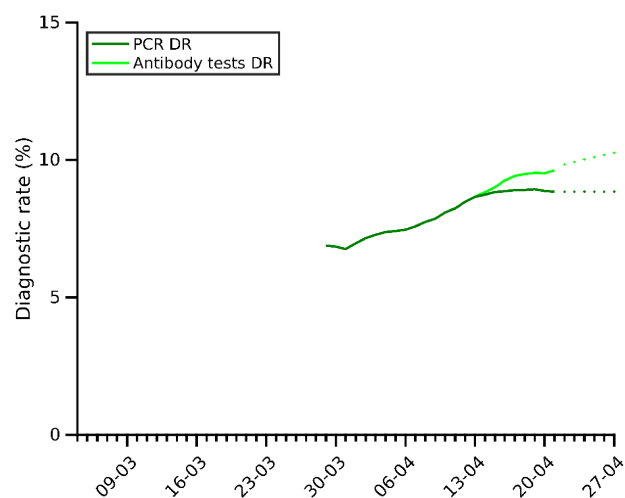
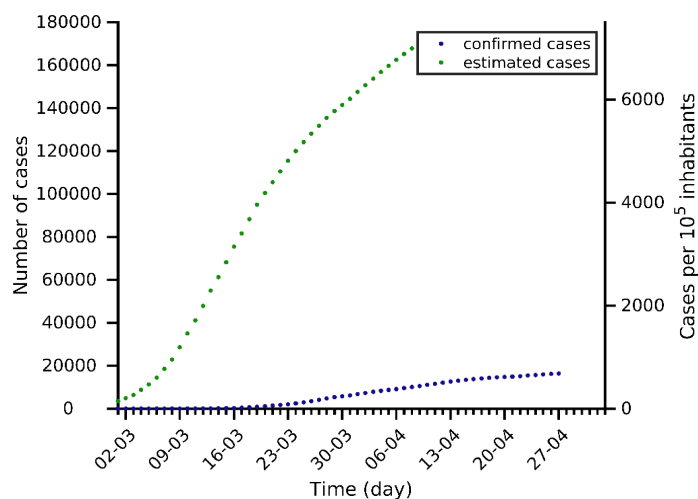
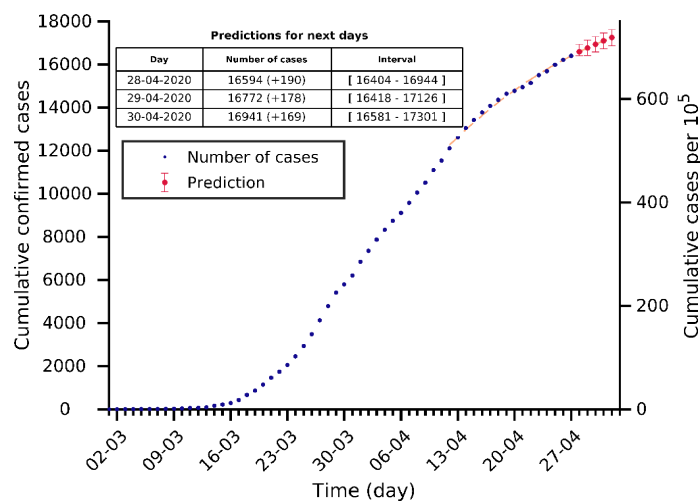
# Madrid 27-04-2020. Population: 6.7M. Current cumulated incidence: 892/10<sup>5</sup>



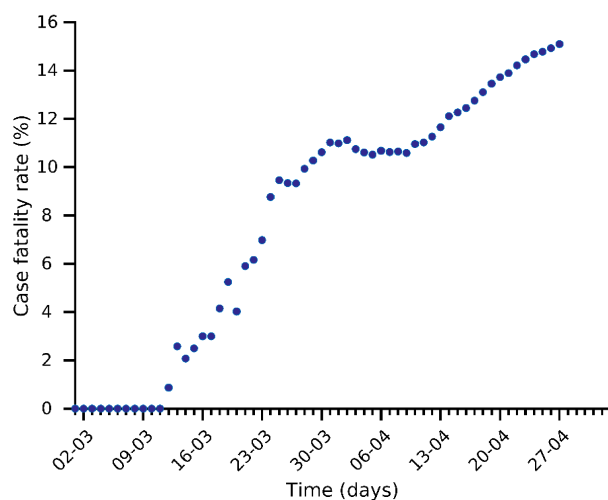
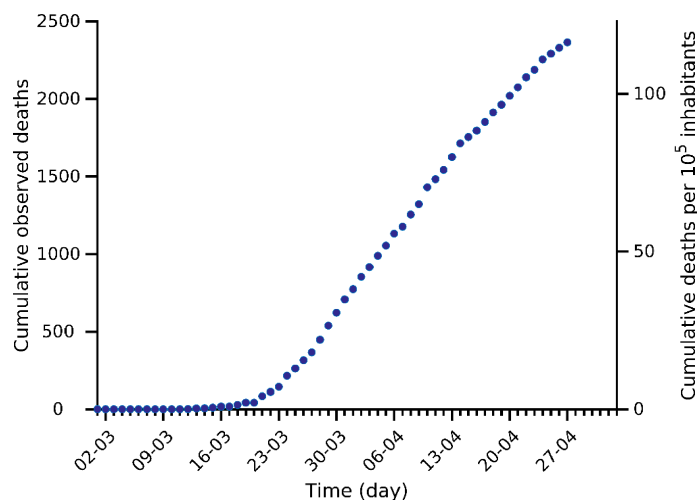
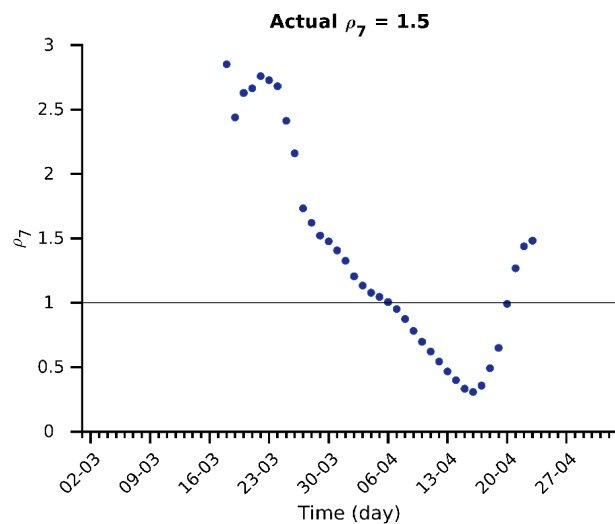
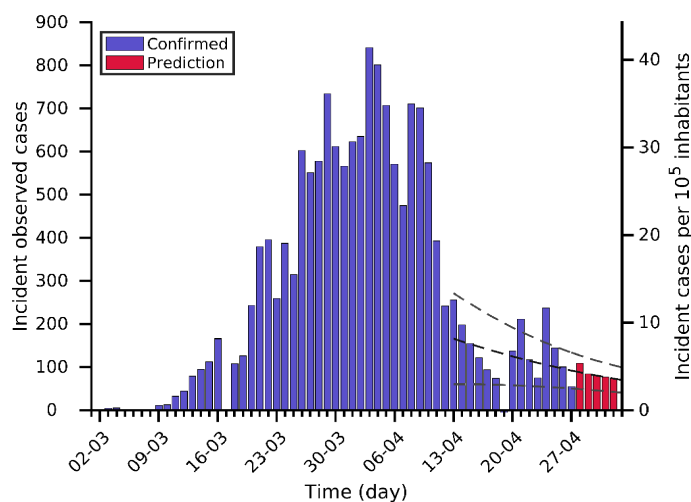
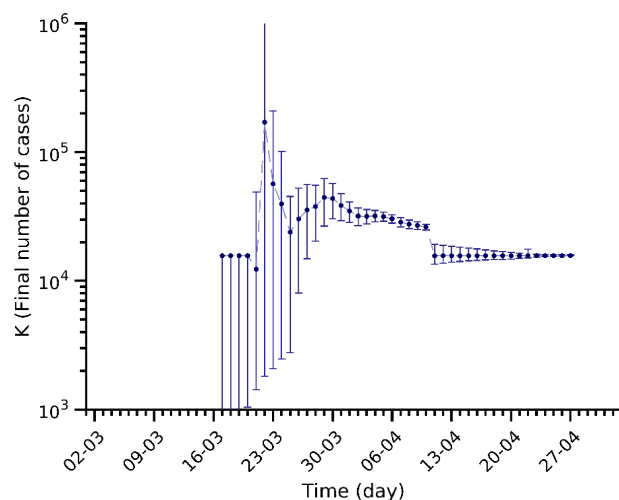
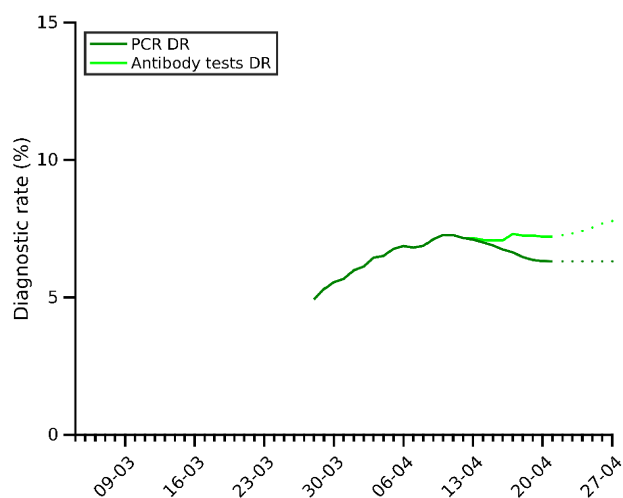
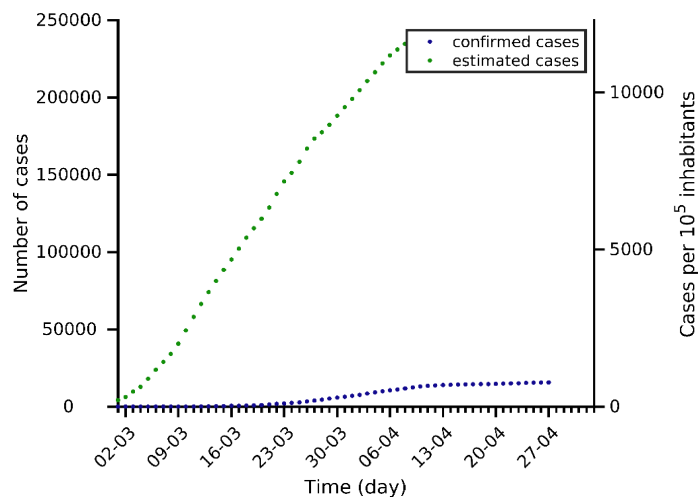
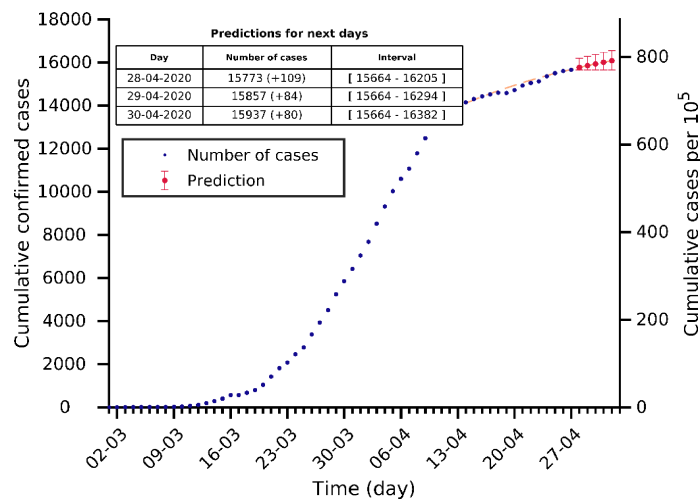
# Catalunya 27-04-2020. Population: 7.7M. Current cumulated incidence: 622/10<sup>5</sup>



# Castilla Leon 27-04-2020. Population: 2.4M. Current cumulated incidence: 684/10<sup>5</sup>

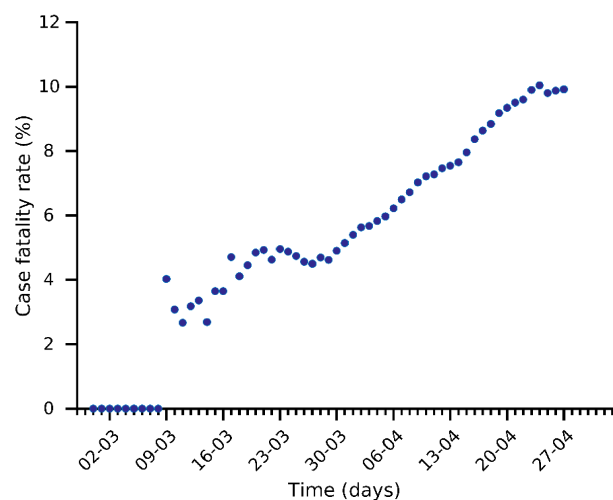
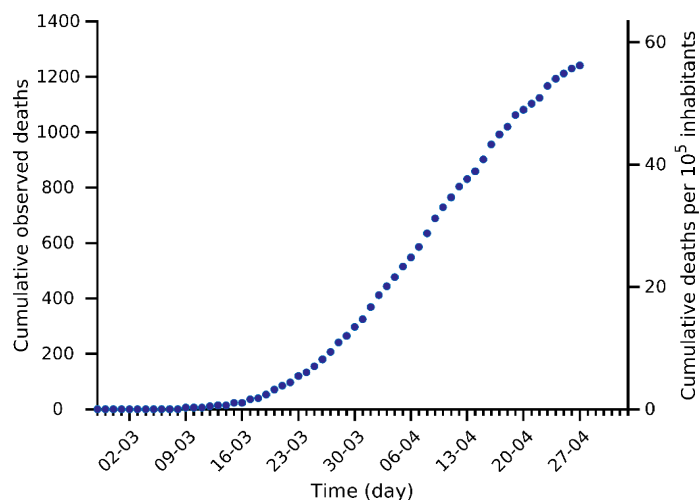
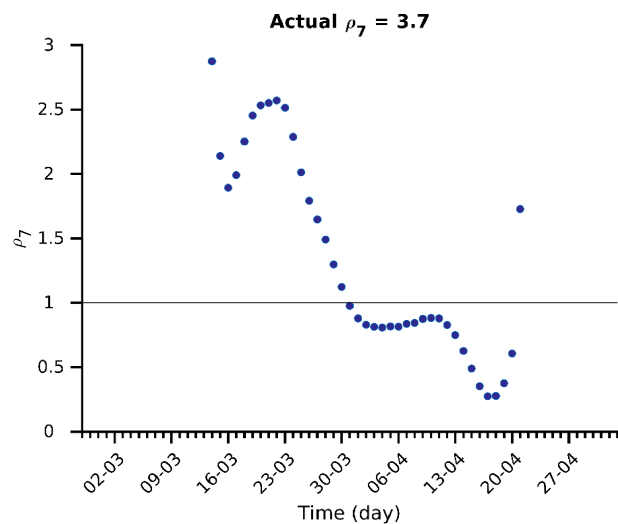
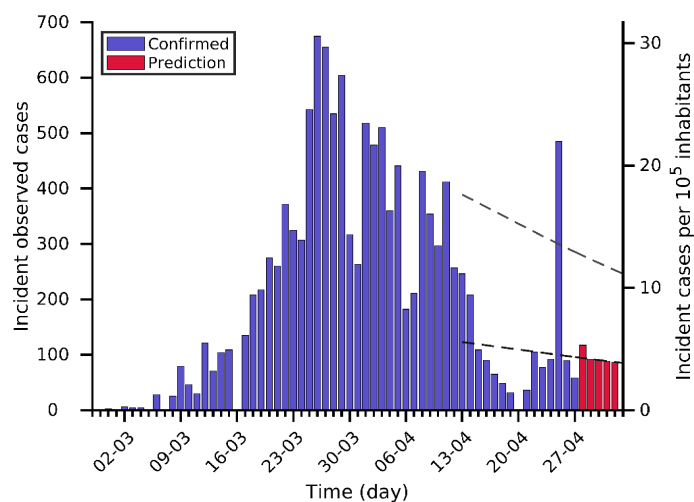
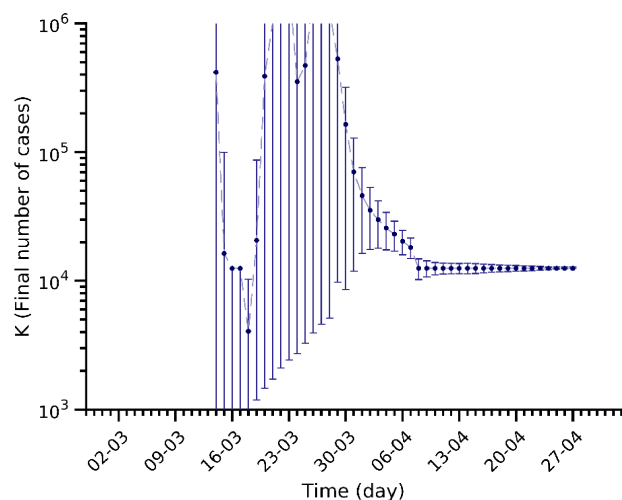
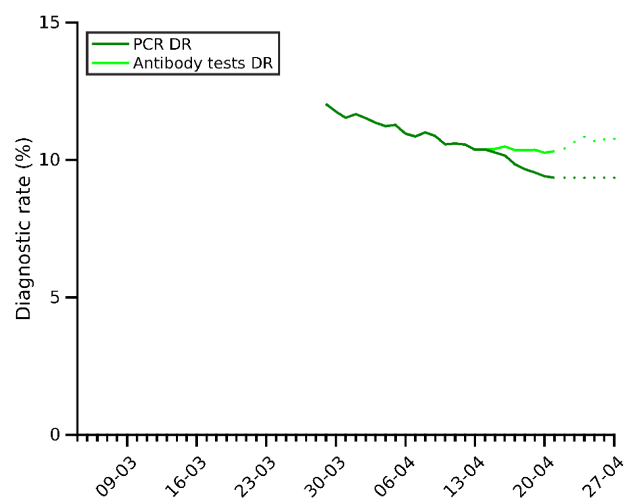
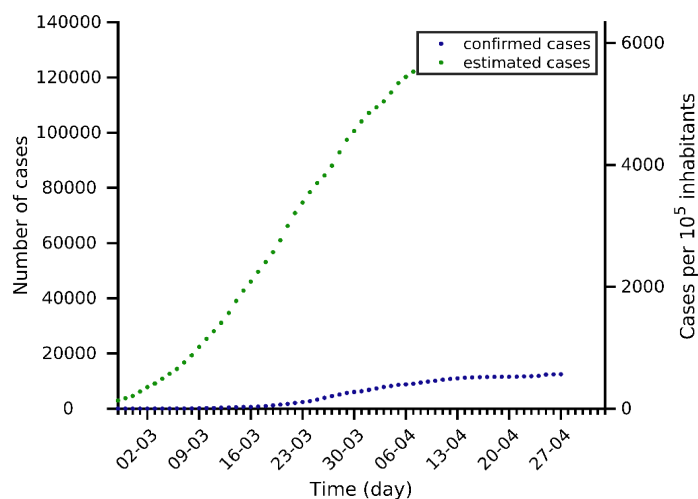
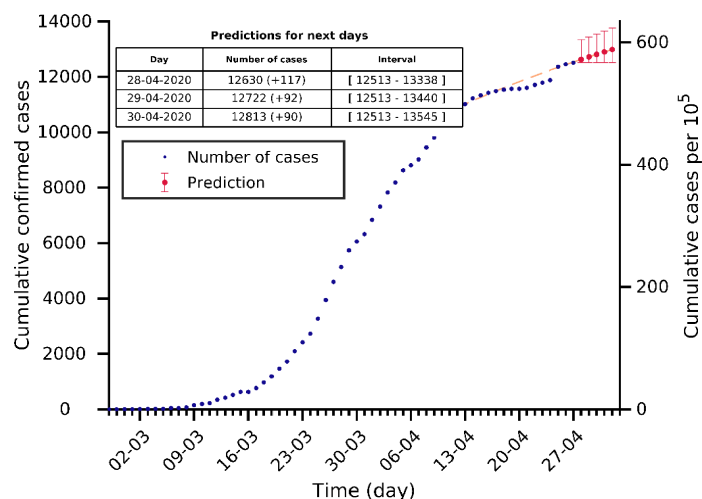


# Castilla-La Mancha 27-04-2020. Population: 2.0M. Current cumulated incidence: 77

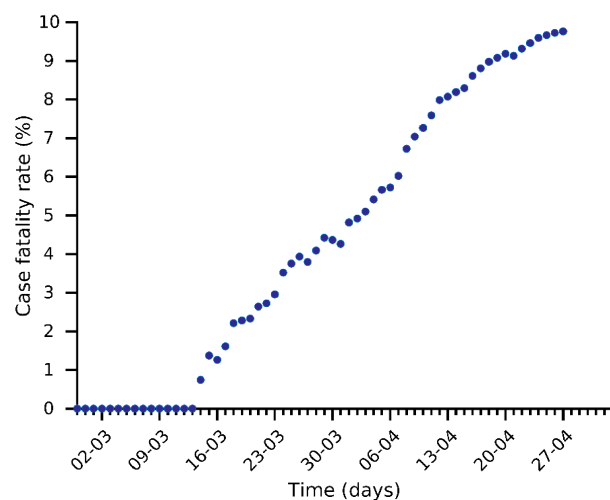
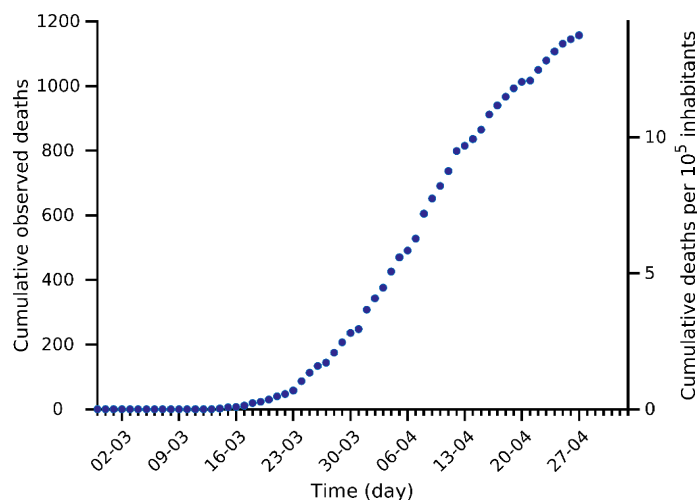
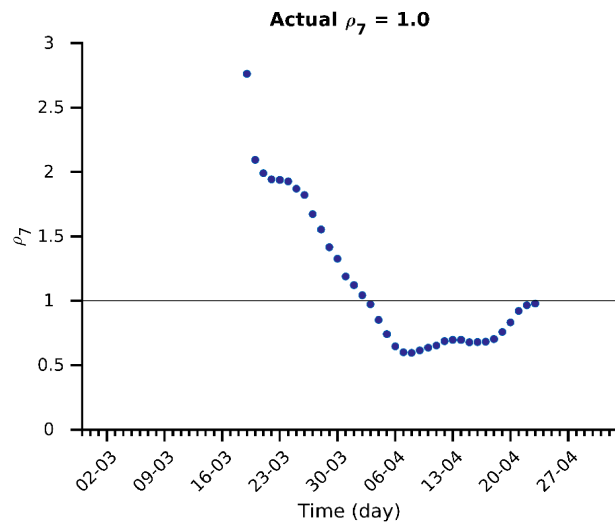
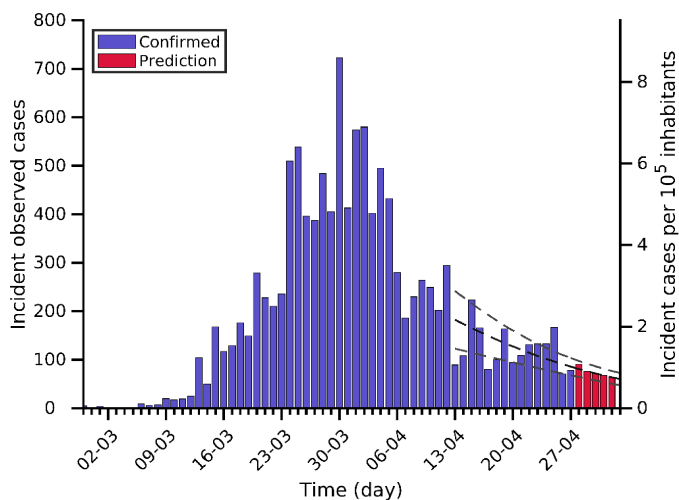
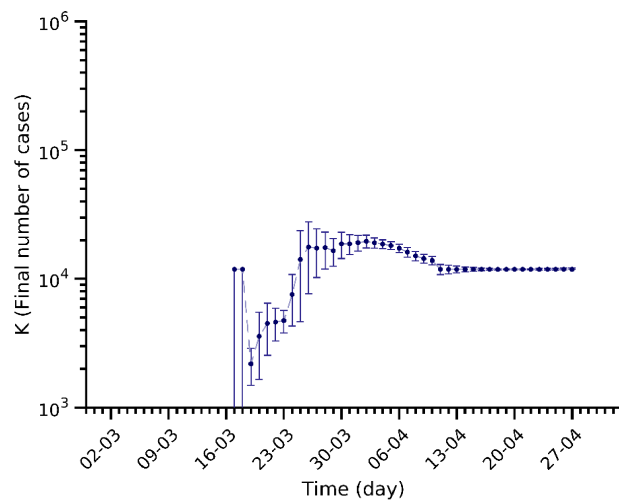
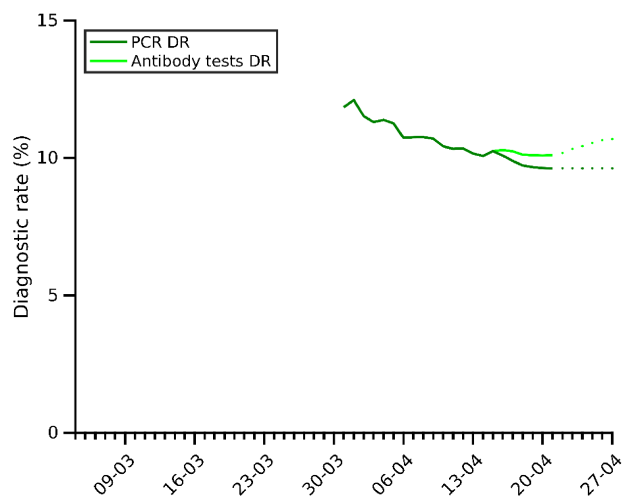
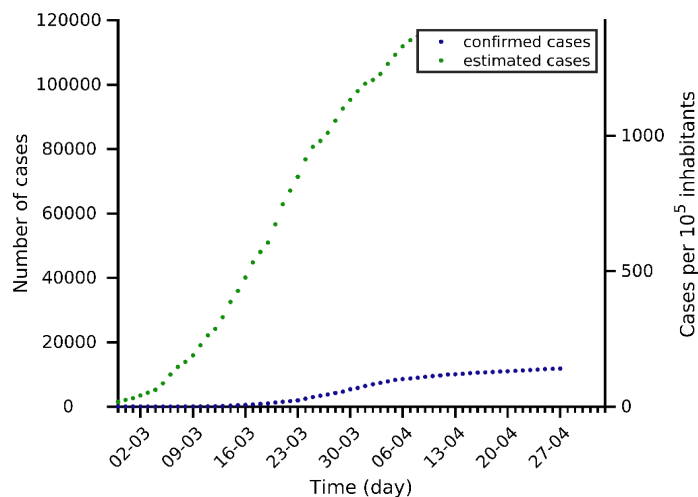
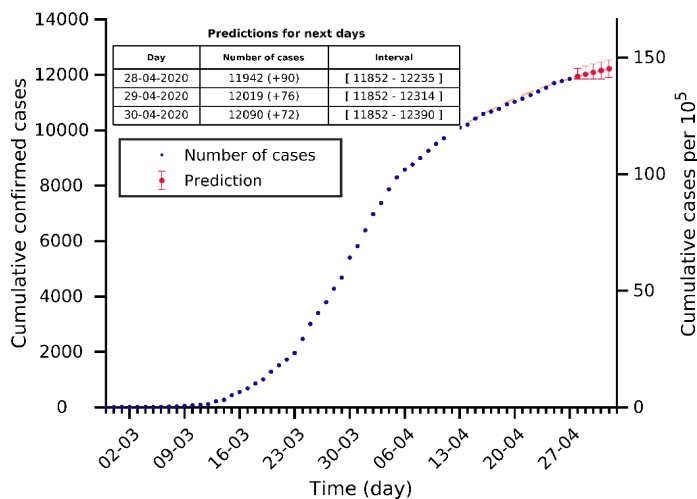




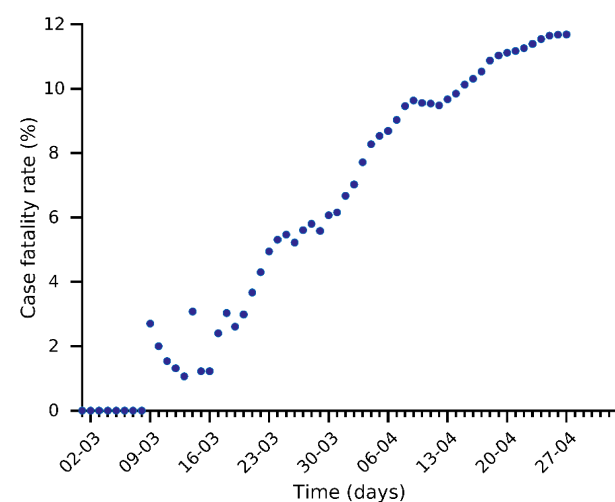
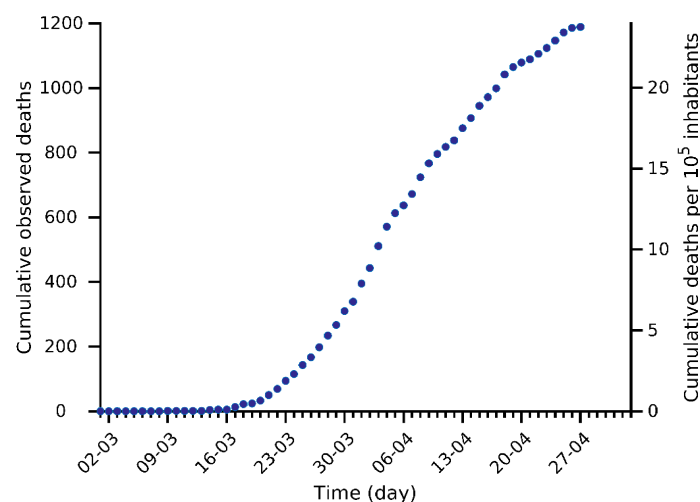
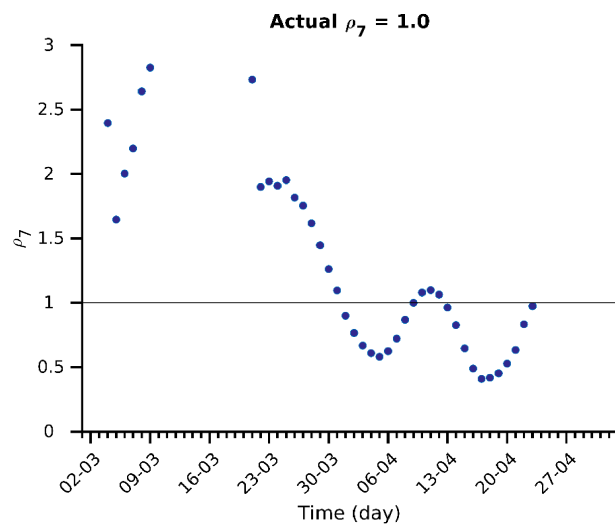
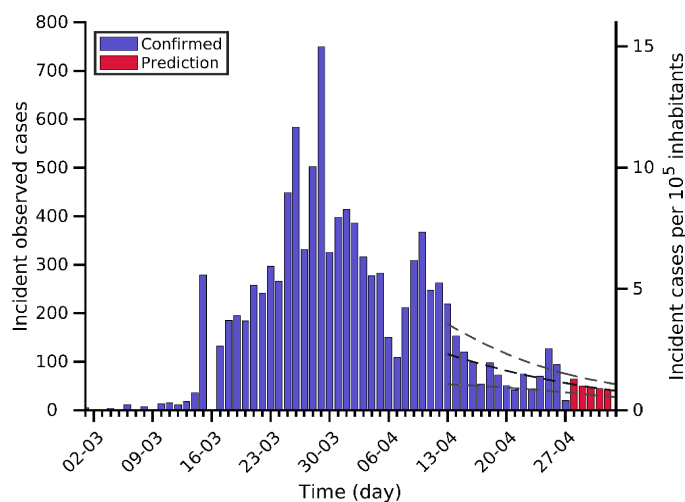
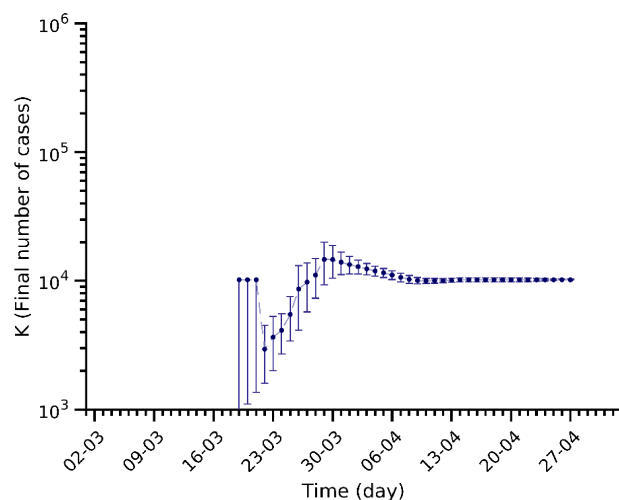
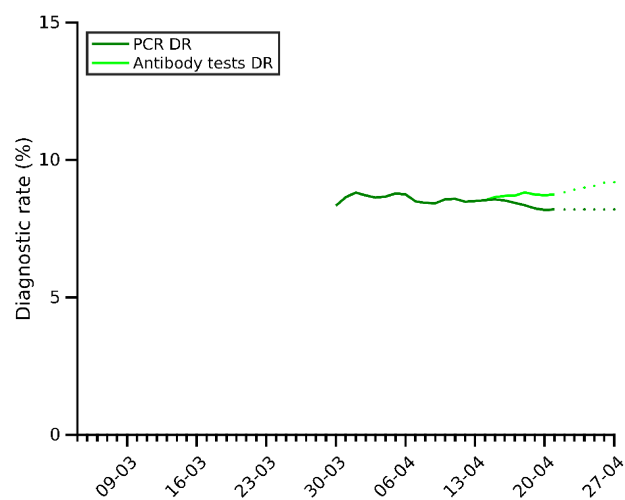
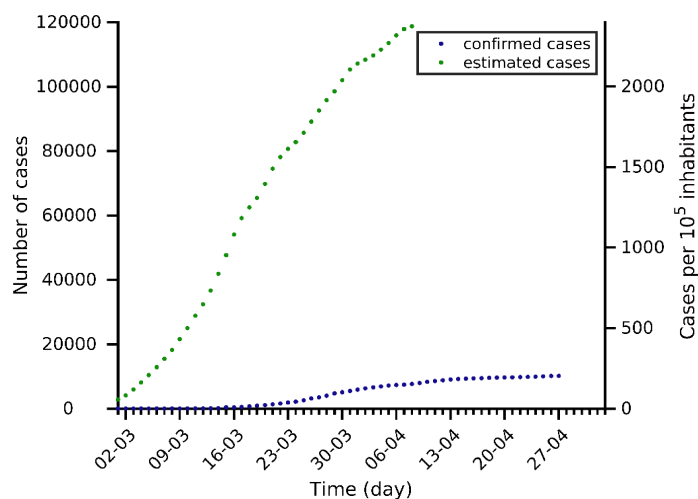
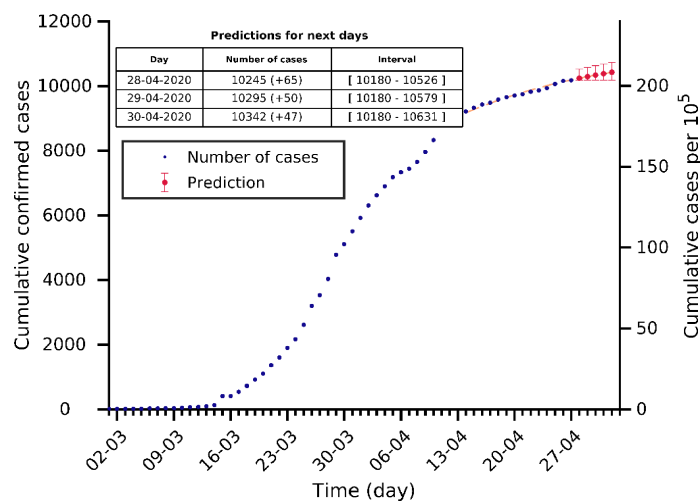
# Euskadi 27-04-2020. Population: 2.2M. Current cumulated incidence: 567/10<sup>5</sup>



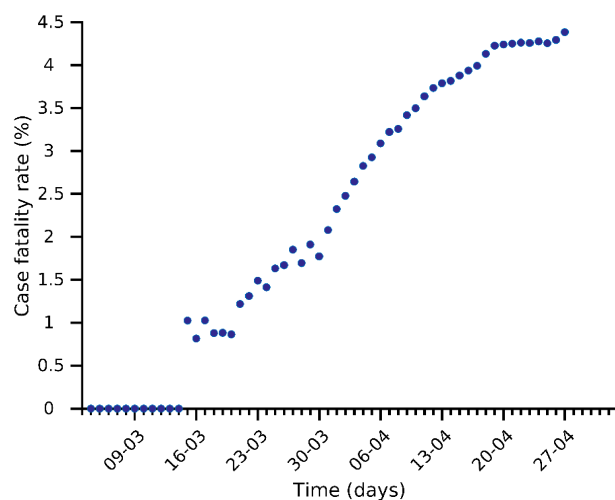
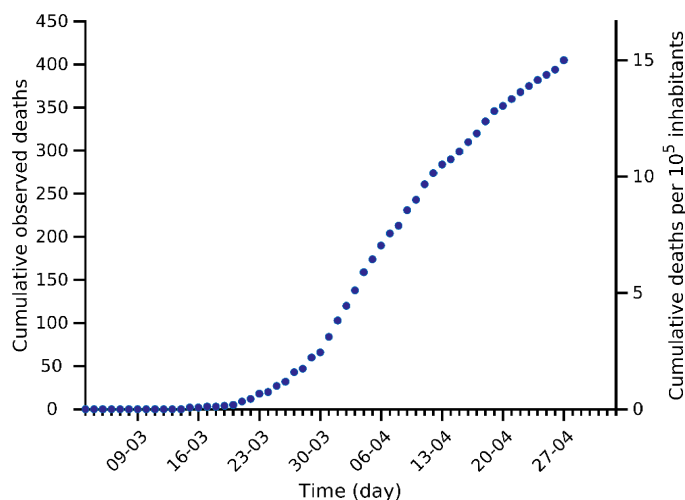
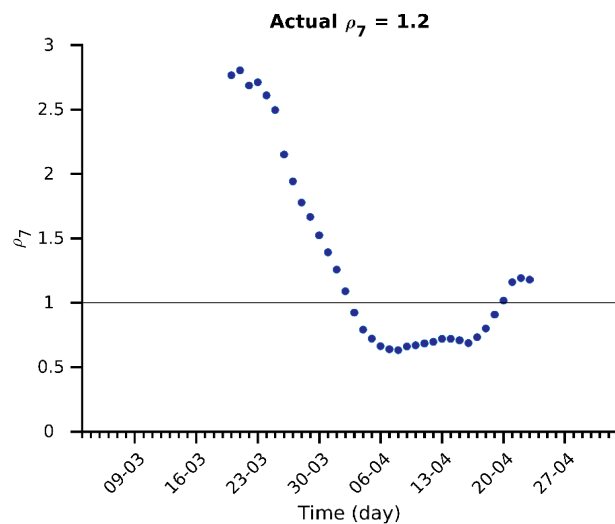
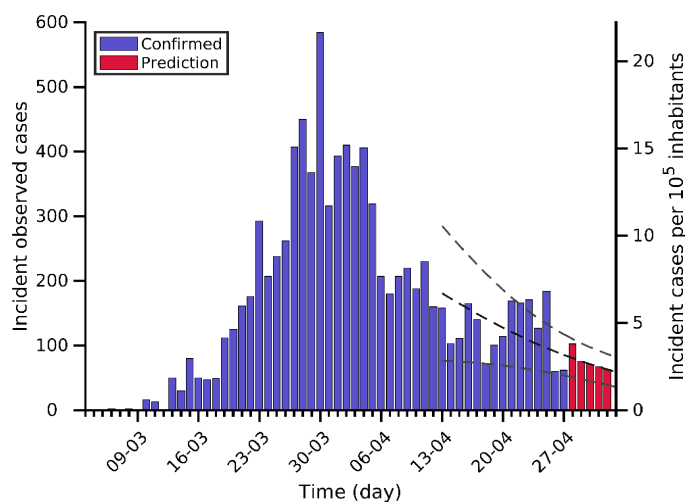
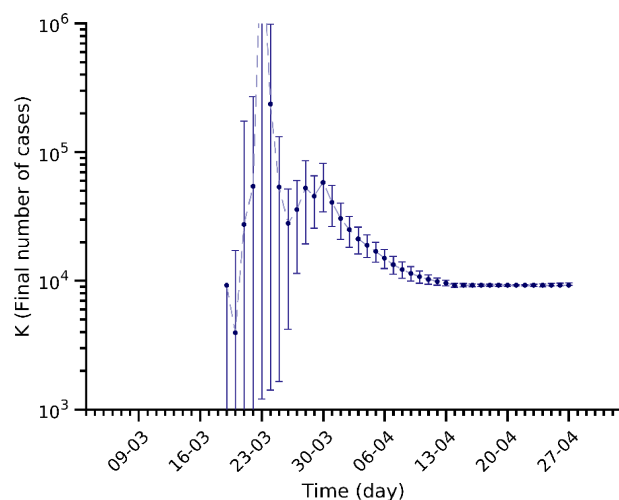
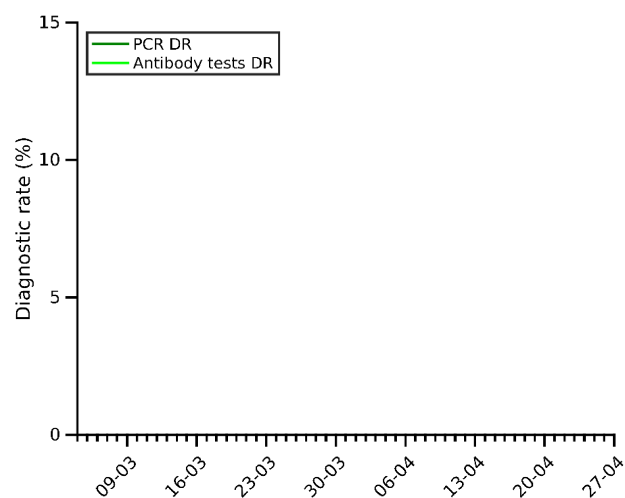
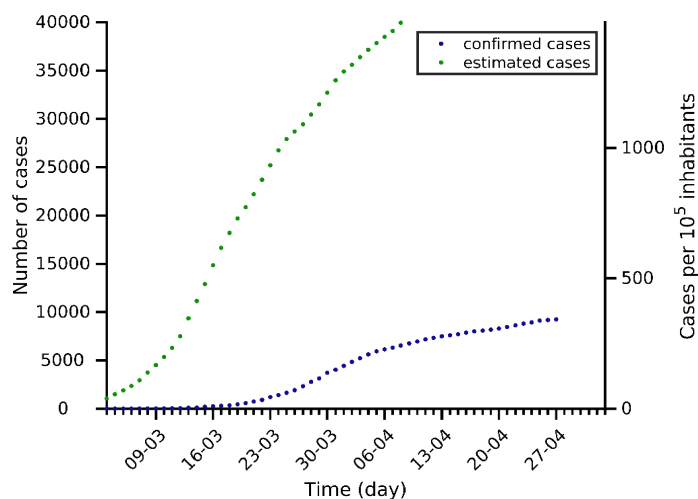
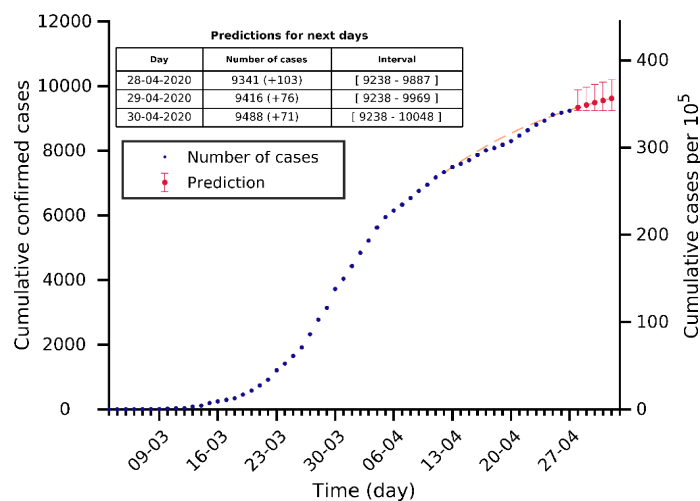
# Andalucia 27-04-2020. Population: 8.4M. Current cumulated incidence: 141/10<sup>5</sup>



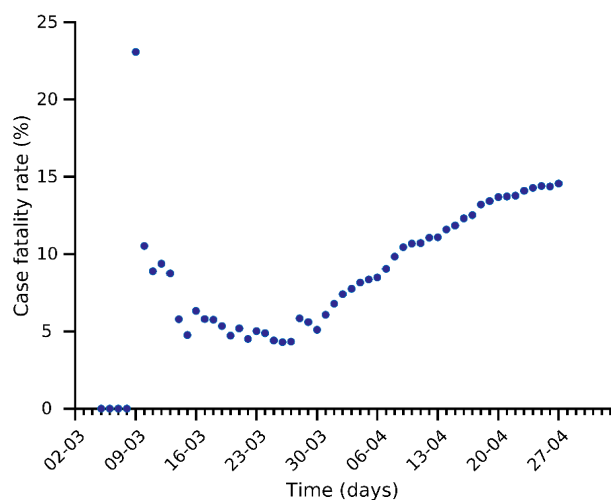
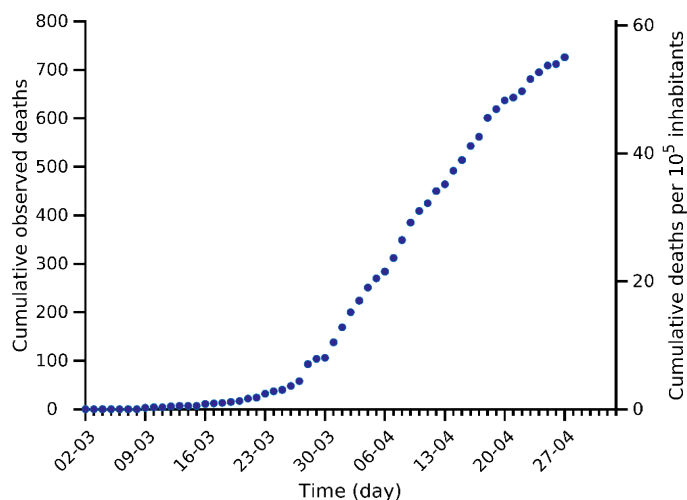
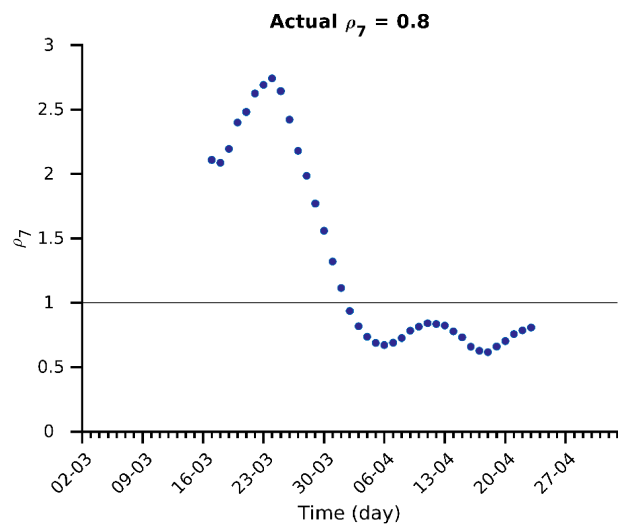
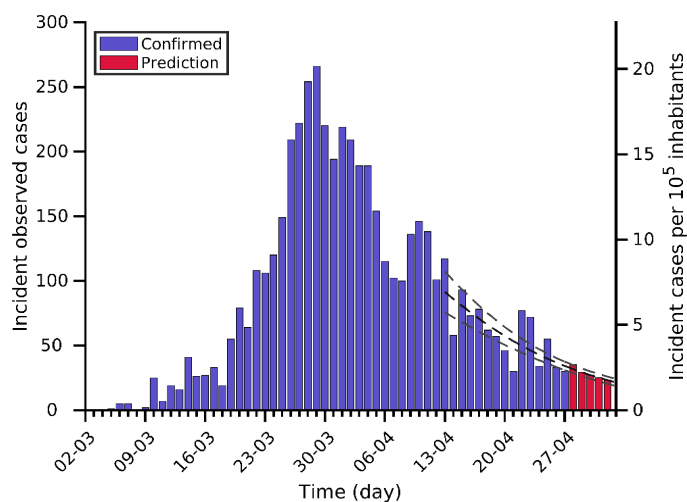
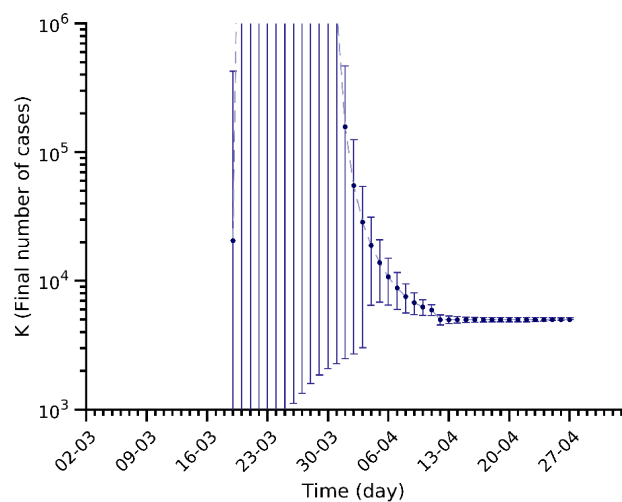
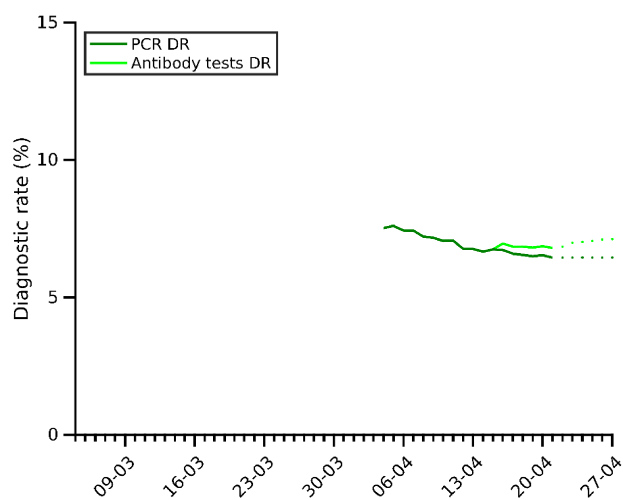
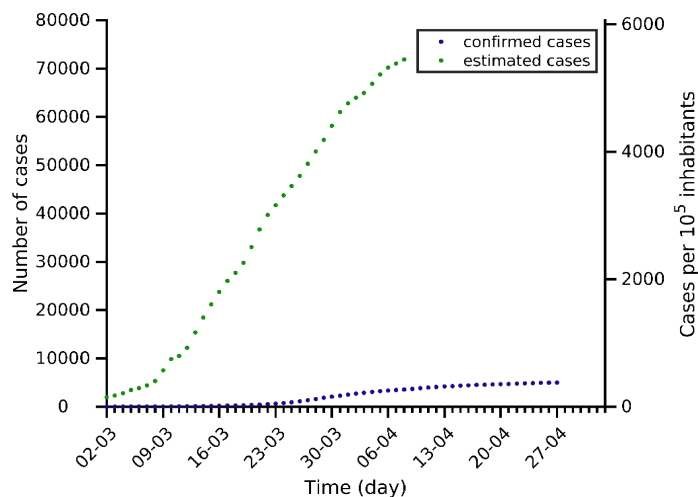
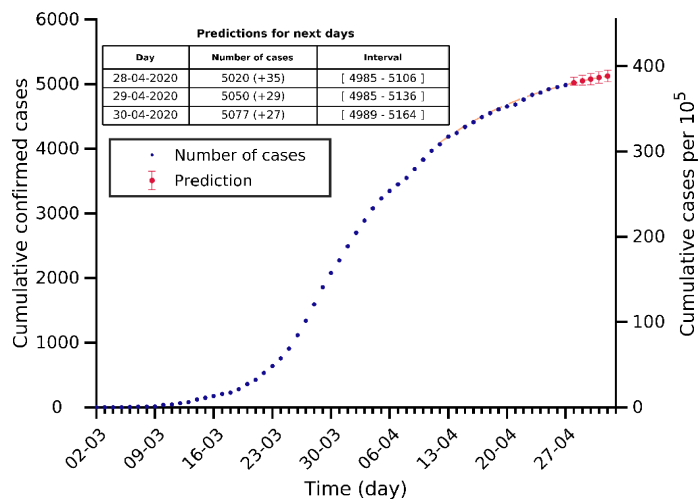
# C Valenciana 27-04-2020. Population: 5.0M. Current cumulated incidence: 203/10<sup>5</sup>



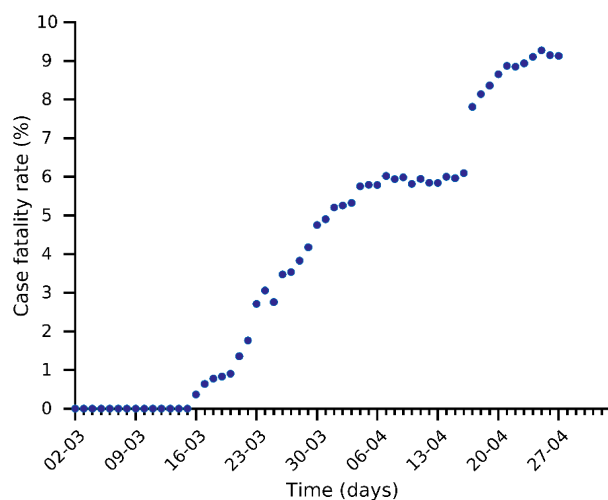
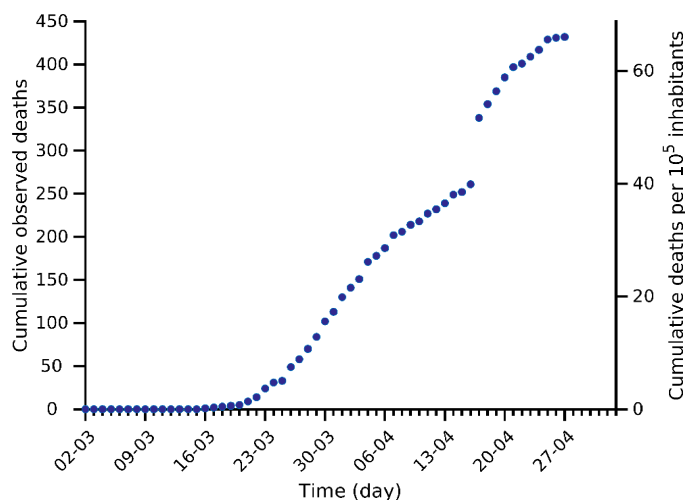
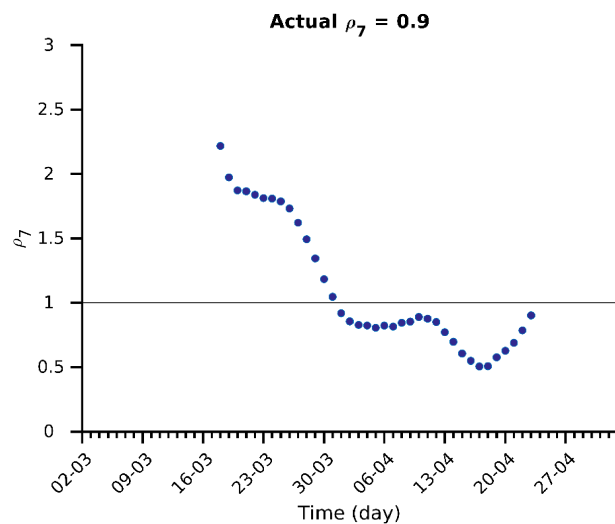
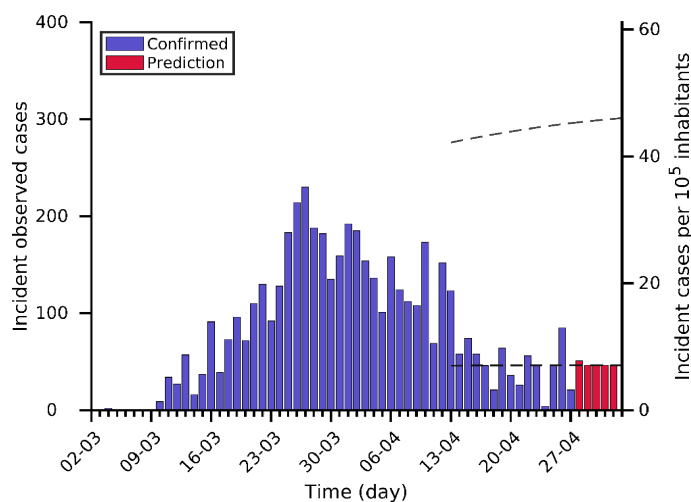
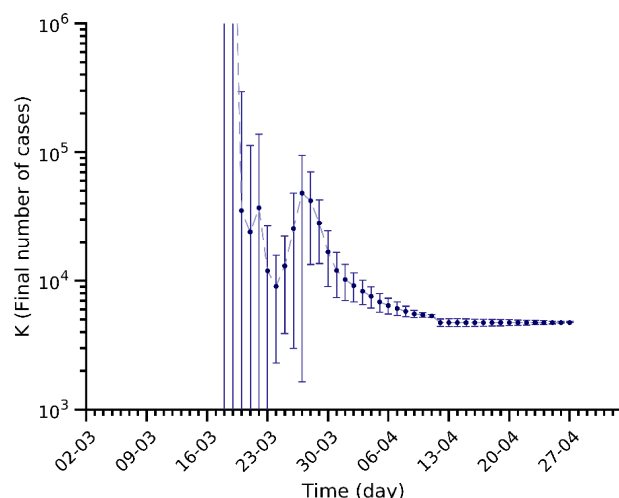
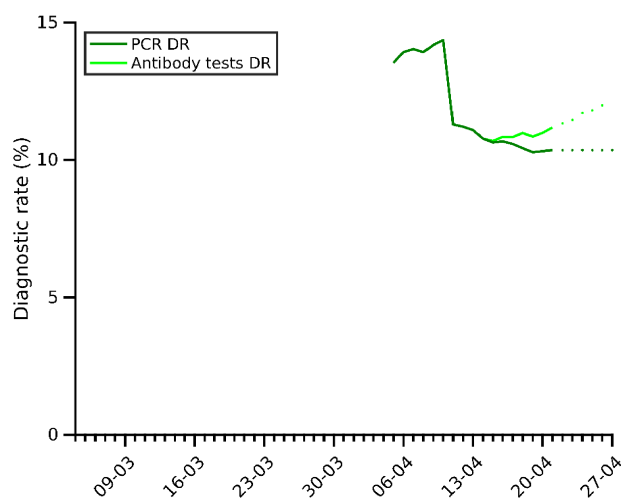
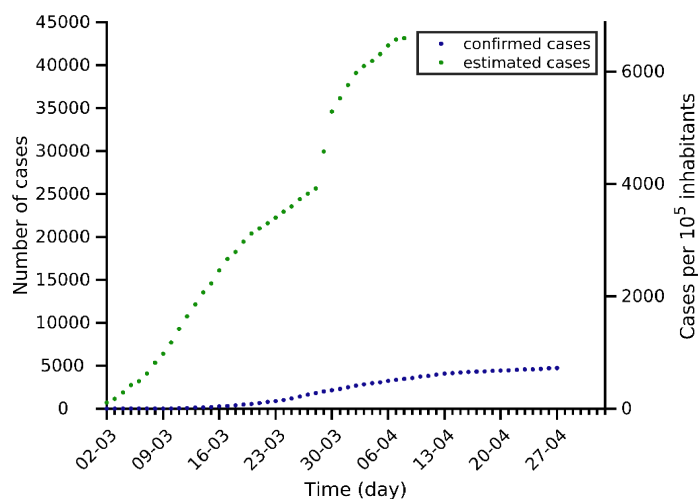
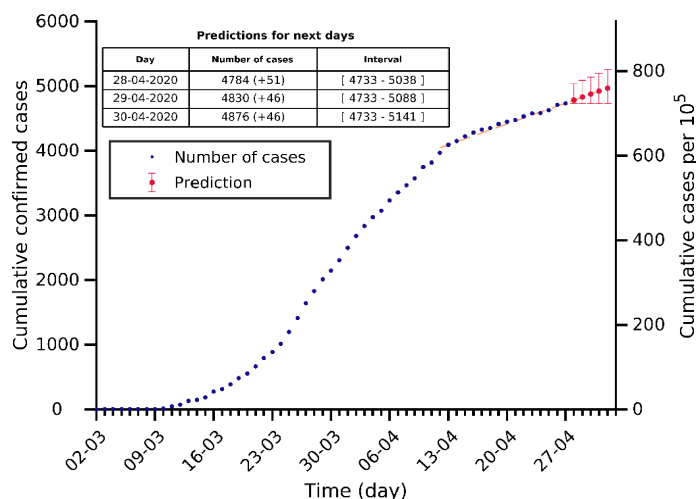
# Galicia 27-04-2020. Population: 2.7M. Current cumulated incidence: 342/10<sup>5</sup>



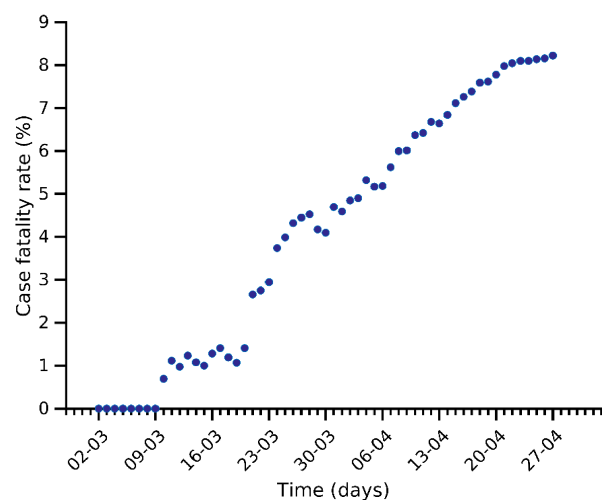
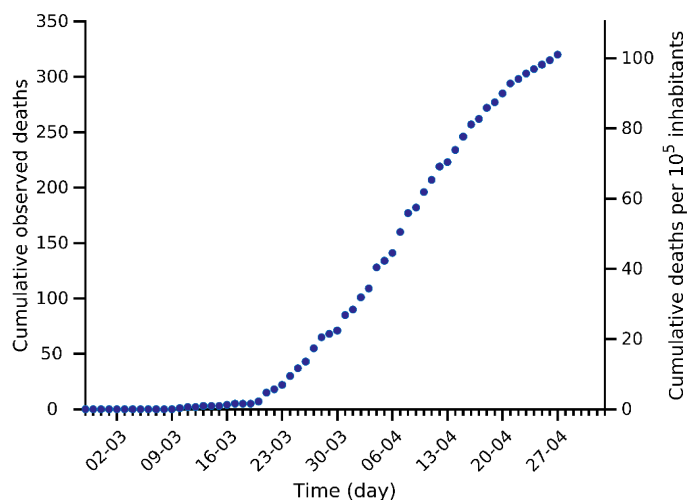
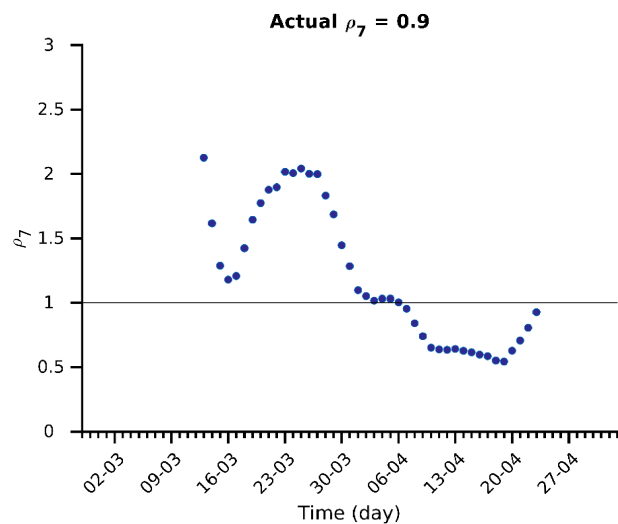
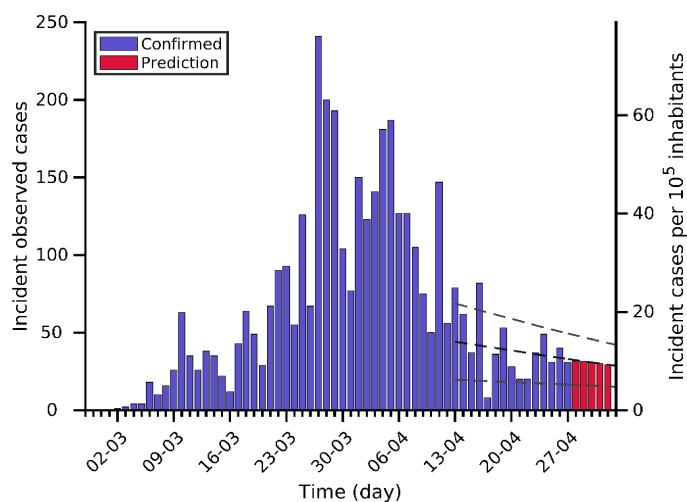
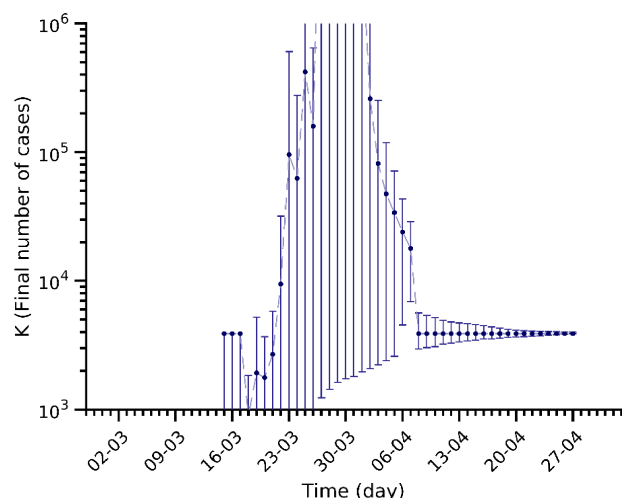
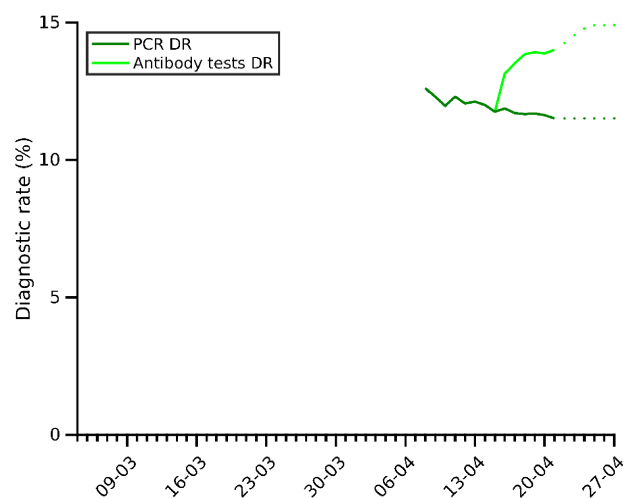
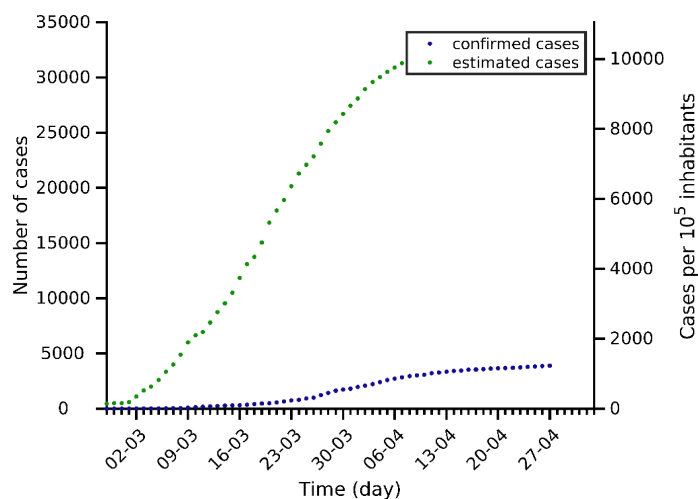
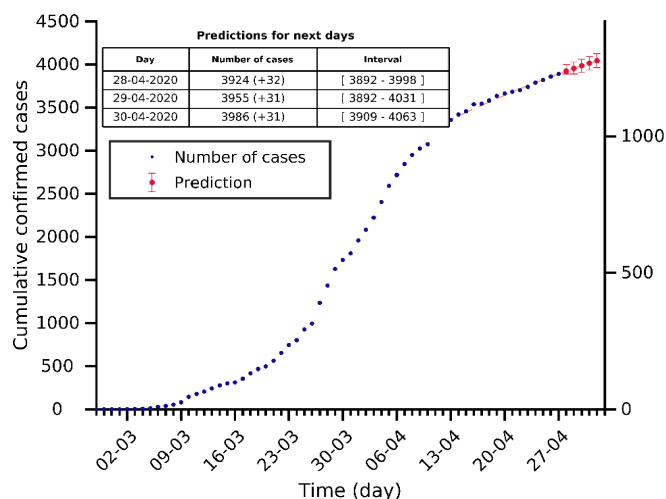
# Aragon 27-04-2020. Population: 1.3M. Current cumulated incidence: 378/10<sup>5</sup>



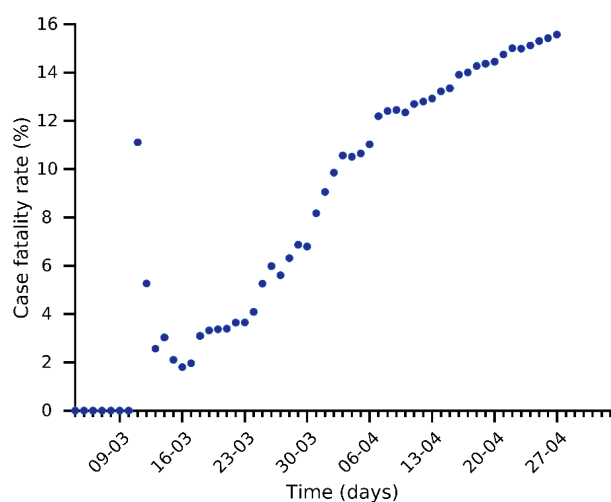
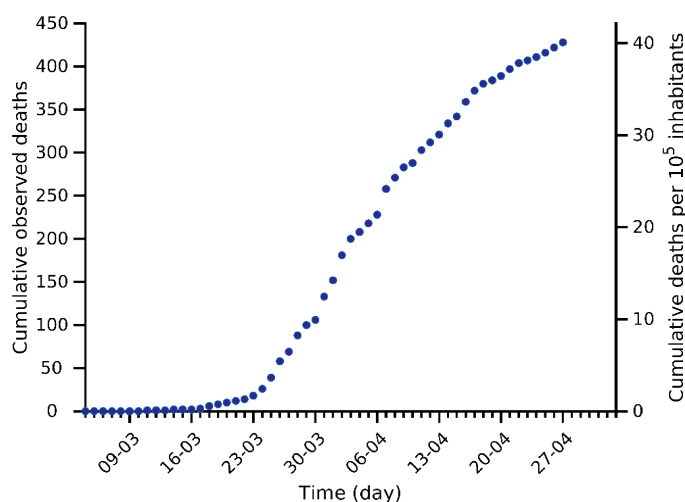
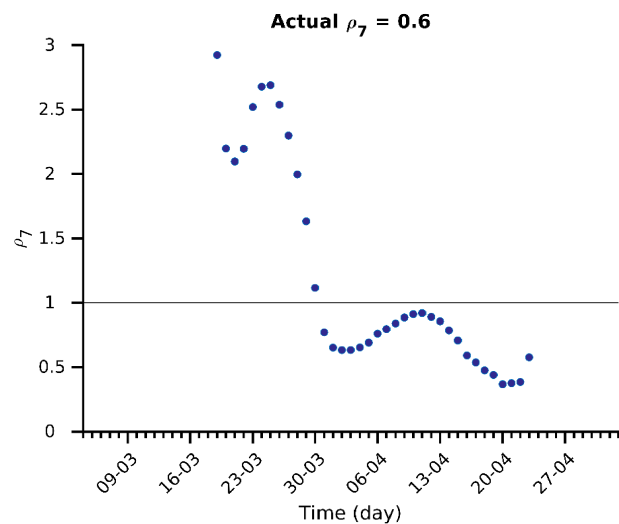
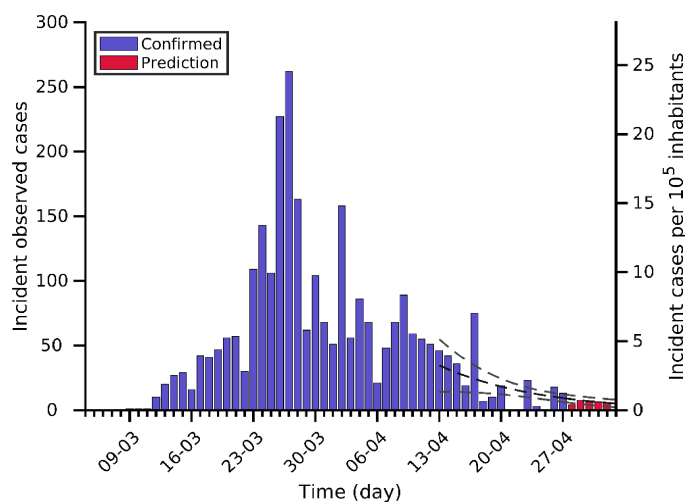
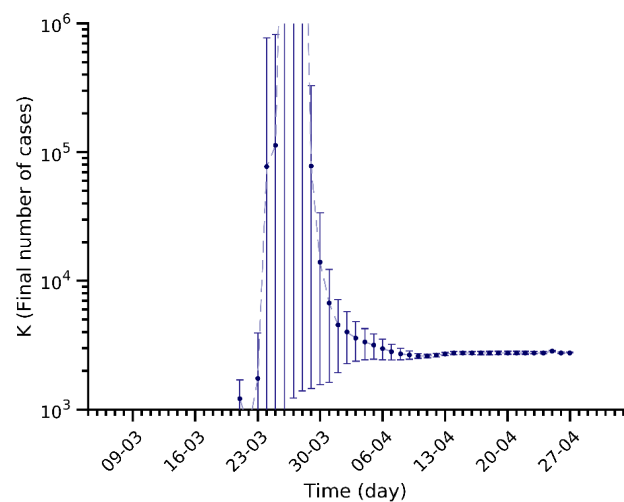
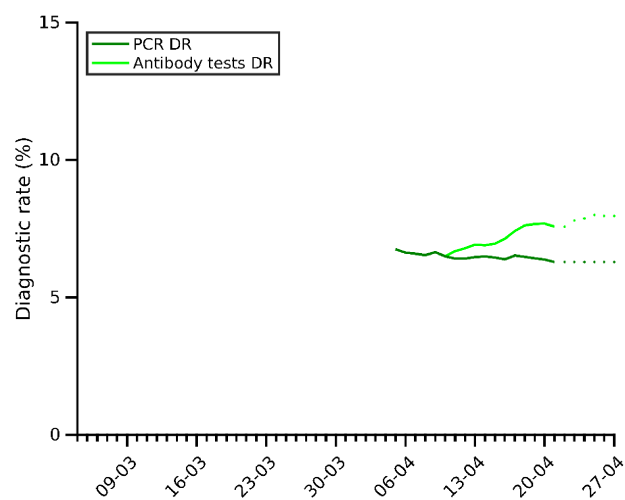
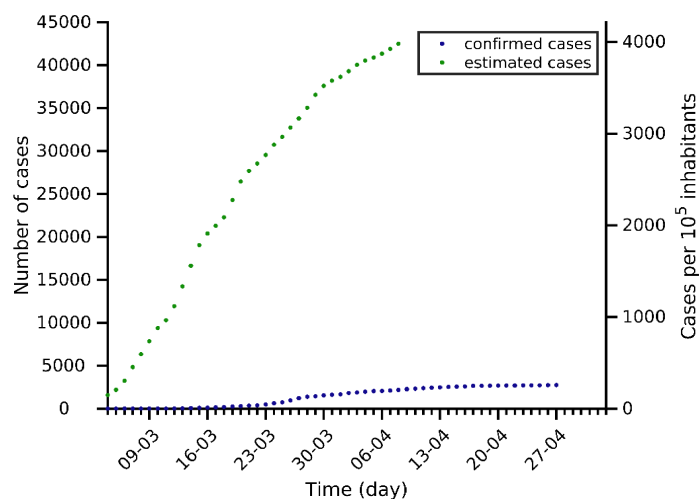
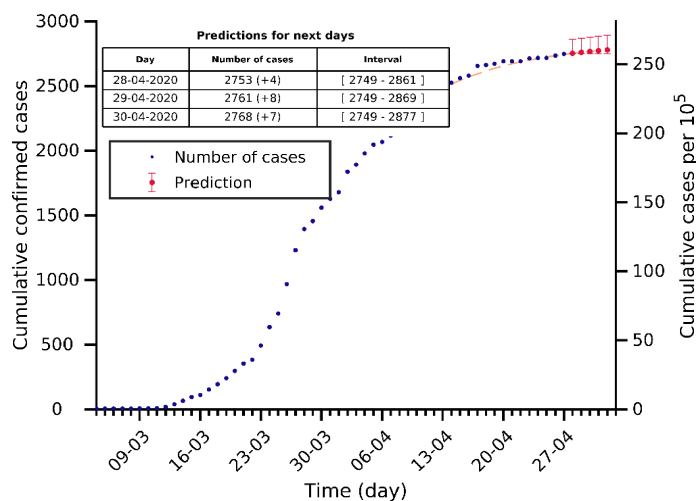
# Navarra 27-04-2020. Population: 0.7M. Current cumulated incidence: 723/10<sup>5</sup>



# La Rioja 27-04-2020. Population: 0.3M. Current cumulated incidence: 1229/10<sup>5</sup>

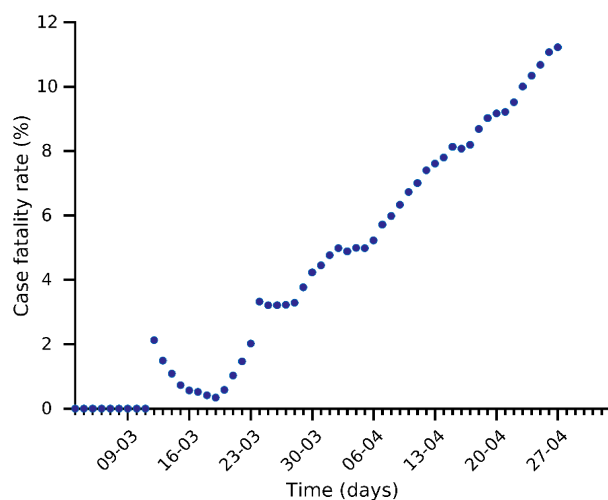
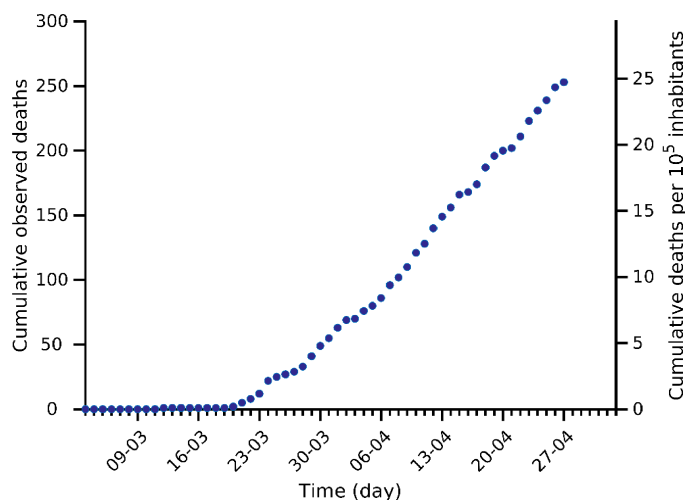
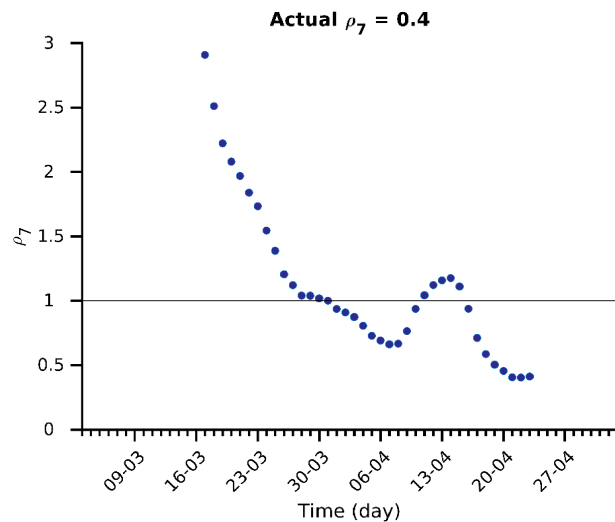
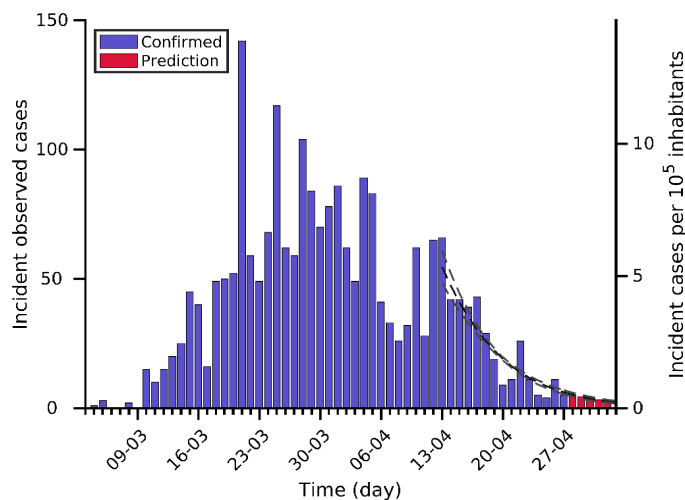
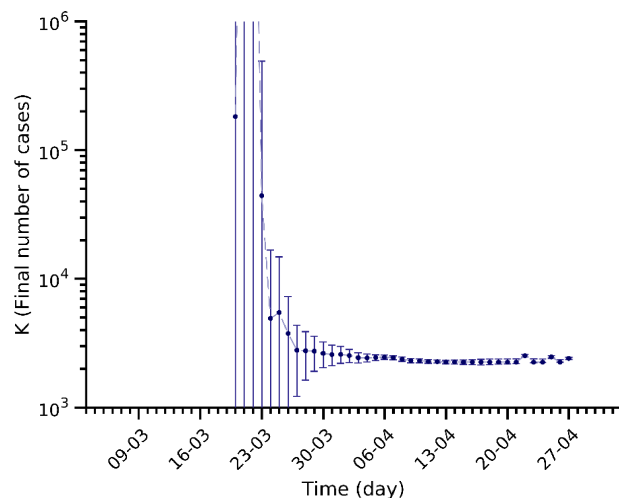
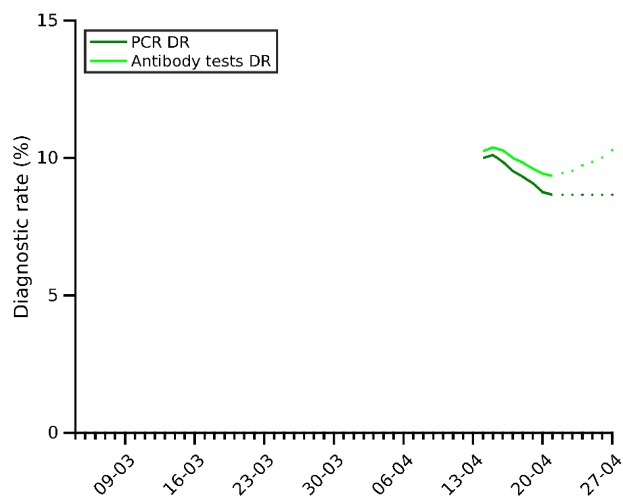
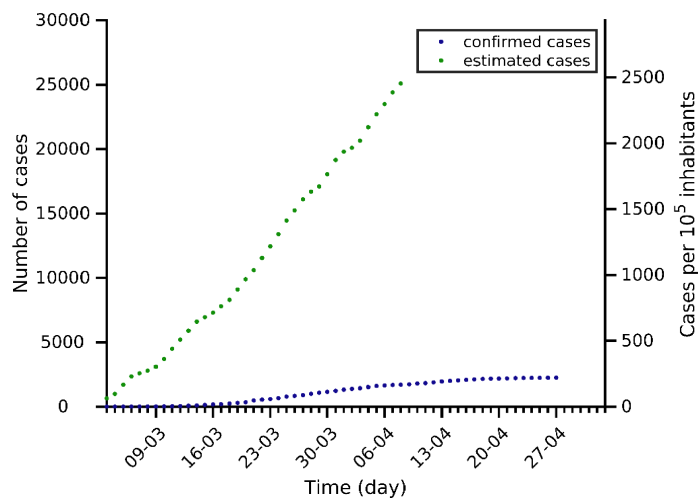
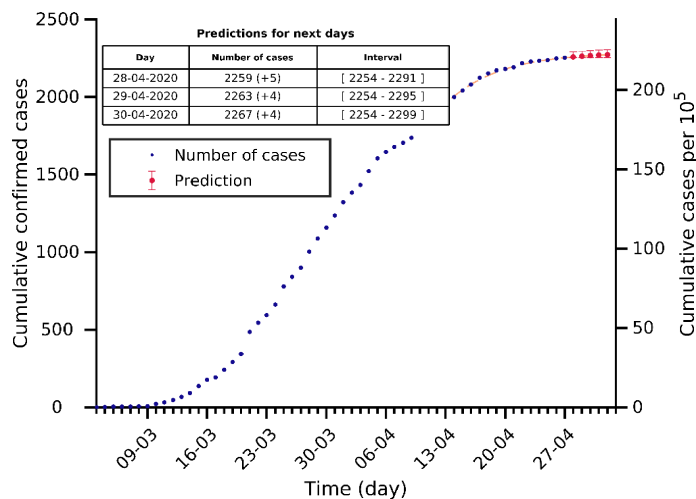


# Extremadura 27-04-2020. Population: 1.1M. Current cumulated incidence: 257/10<sup>5</sup>

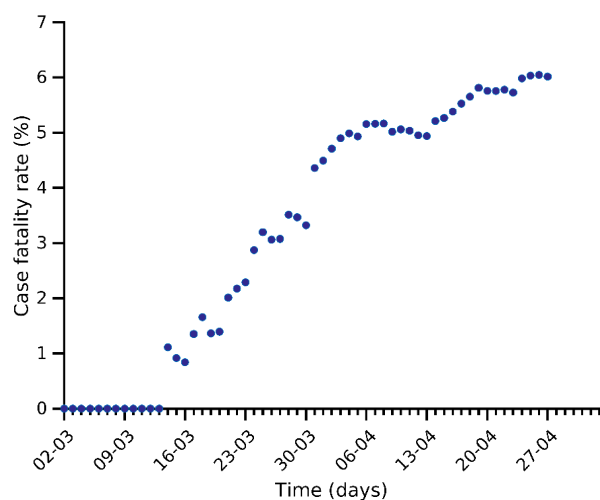
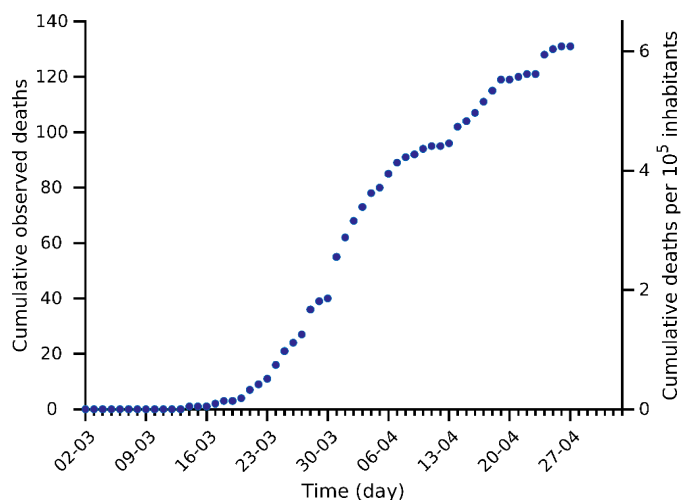
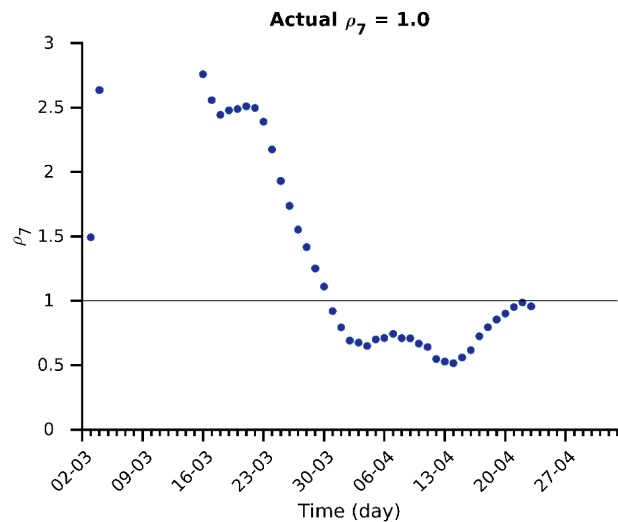
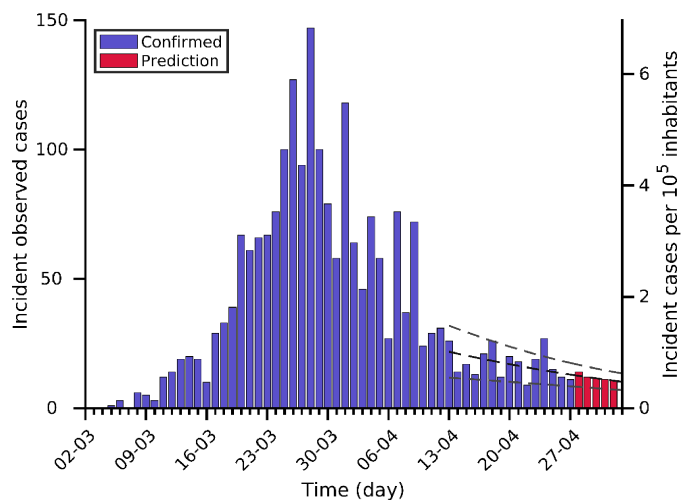
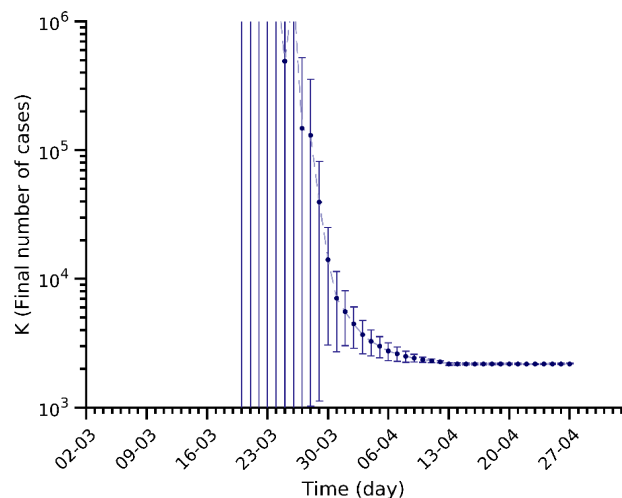
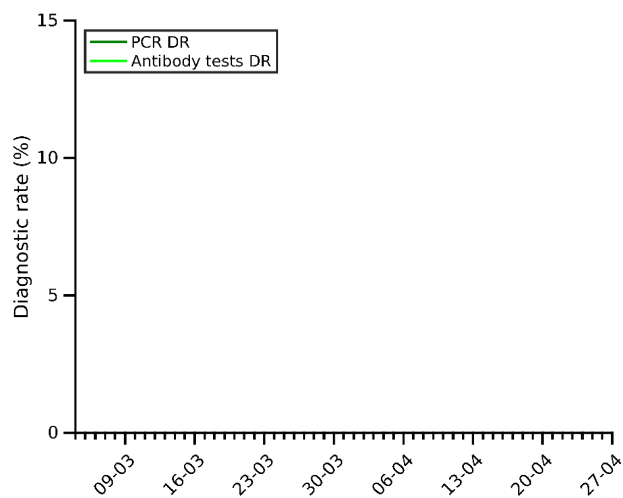
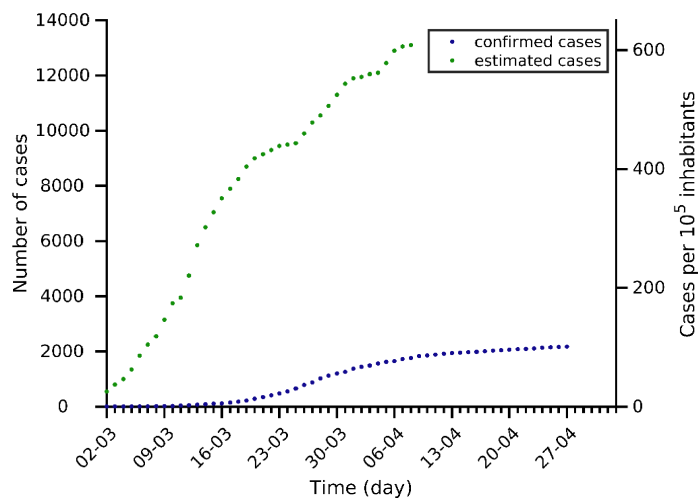
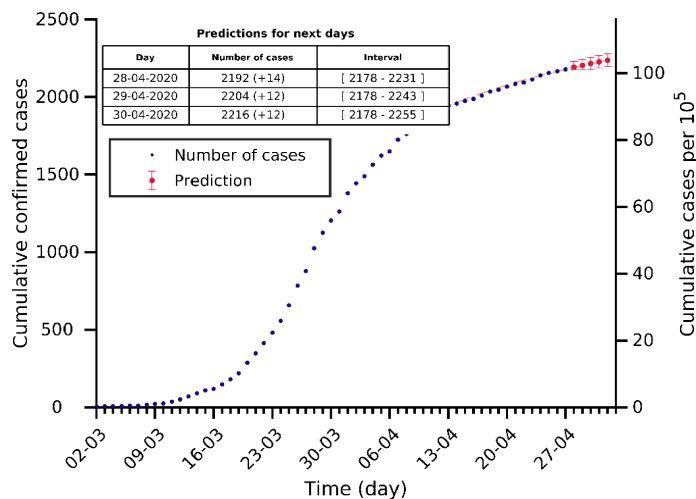




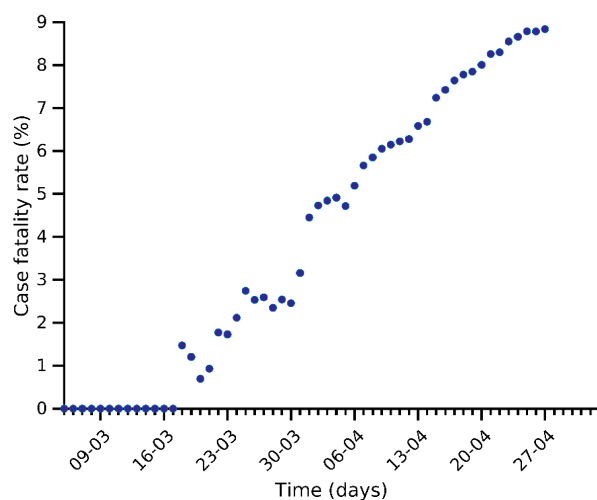
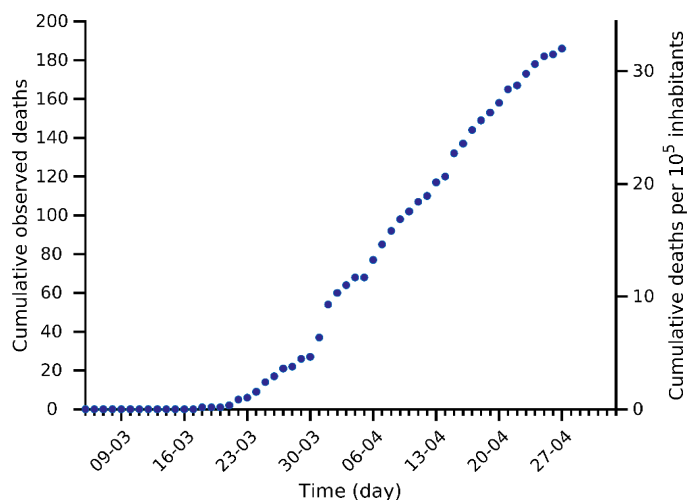
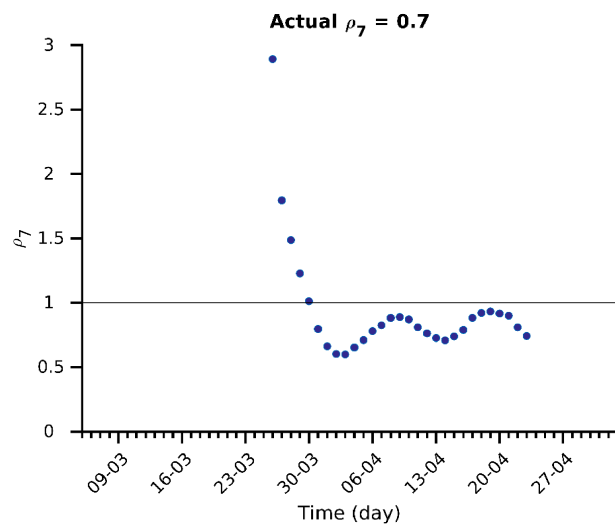
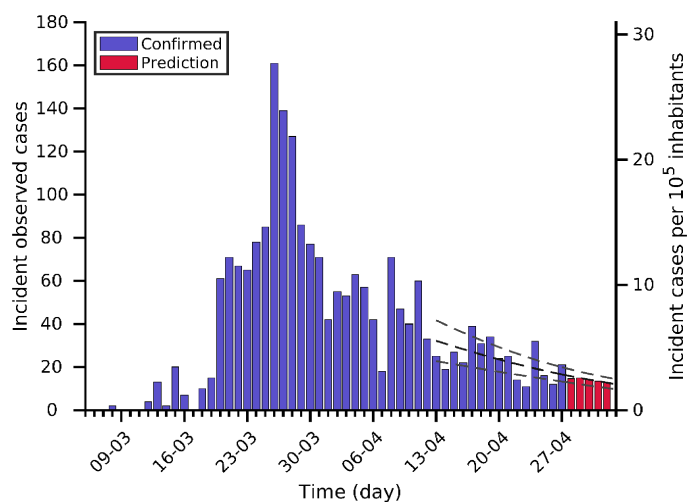
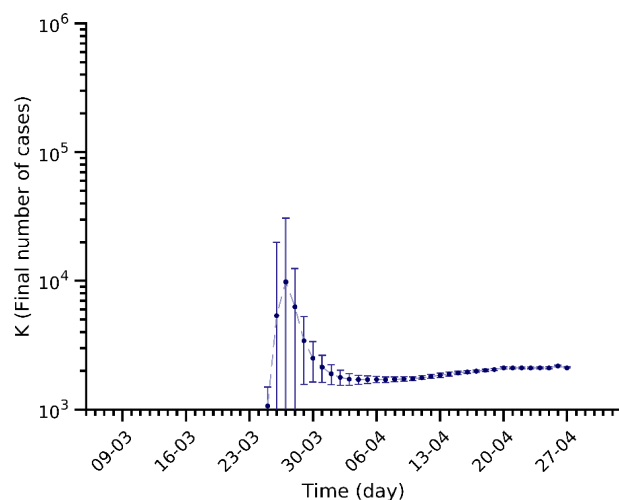
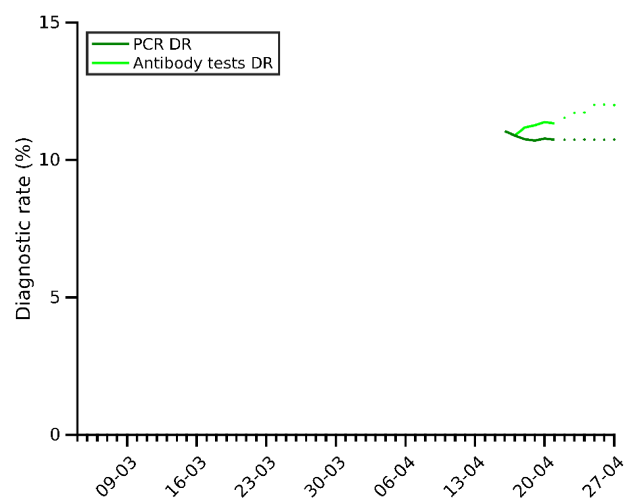
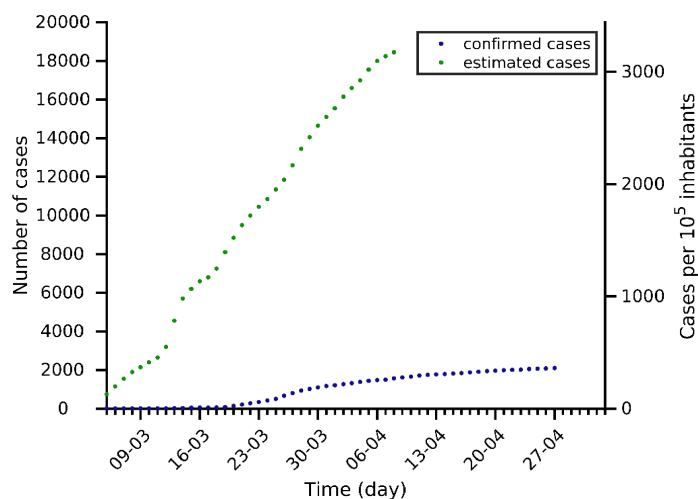
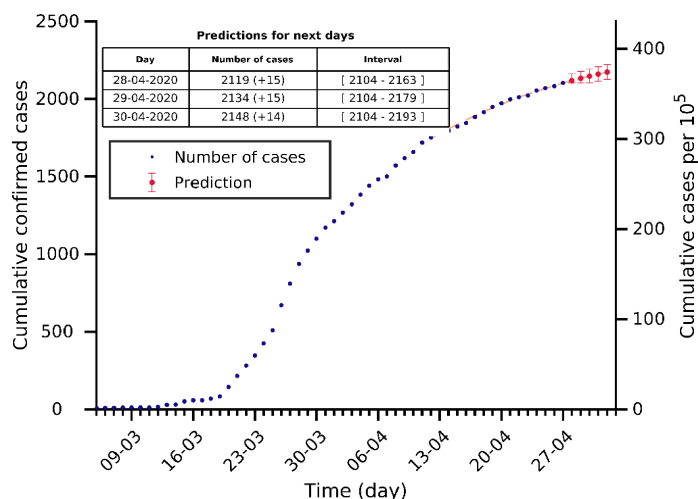
# Asturias 27-04-2020. Population: 1.0M. Current cumulated incidence: 220/10<sup>5</sup>



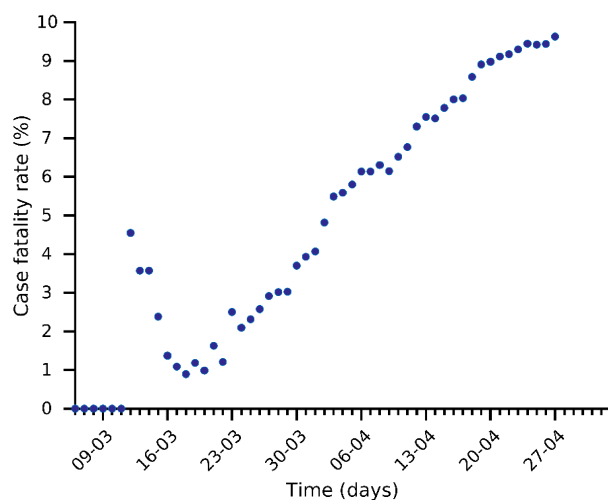
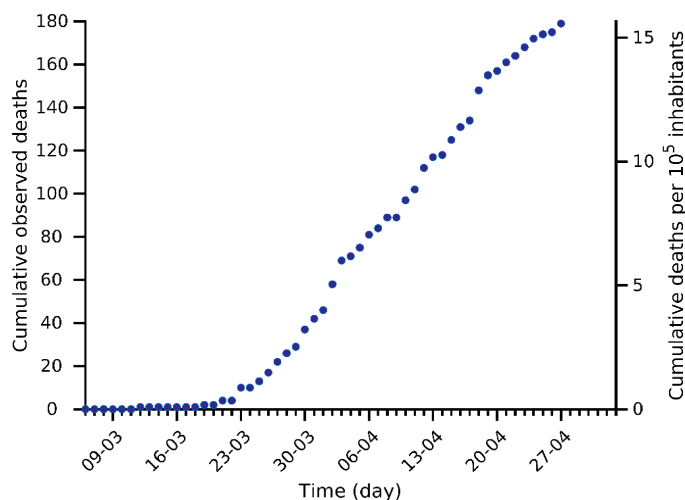
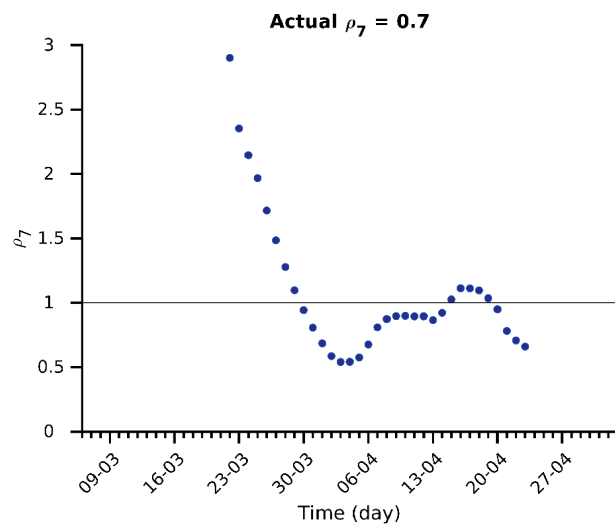
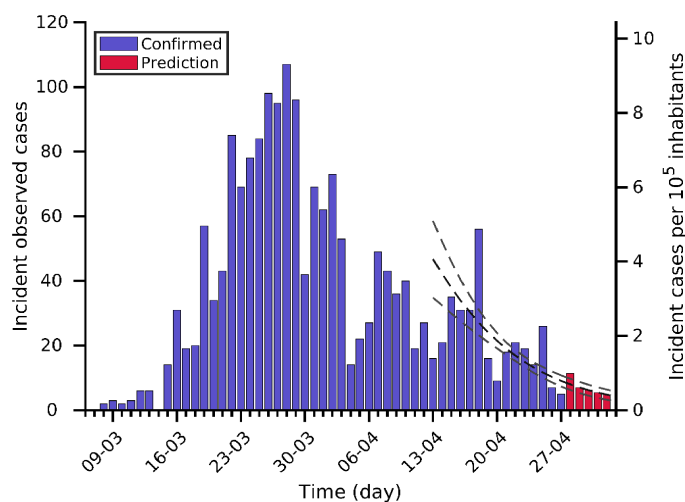
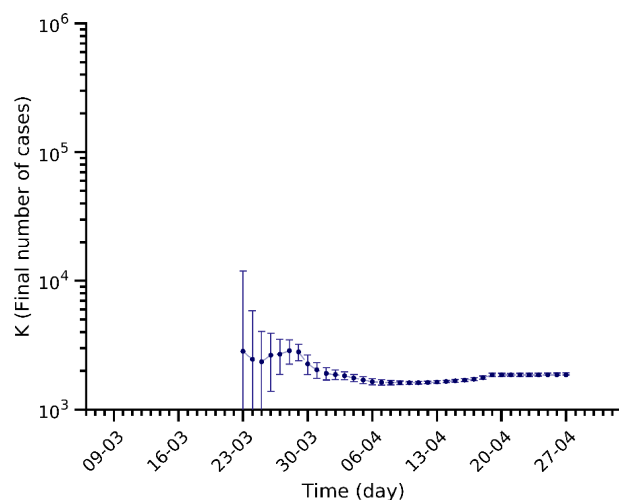
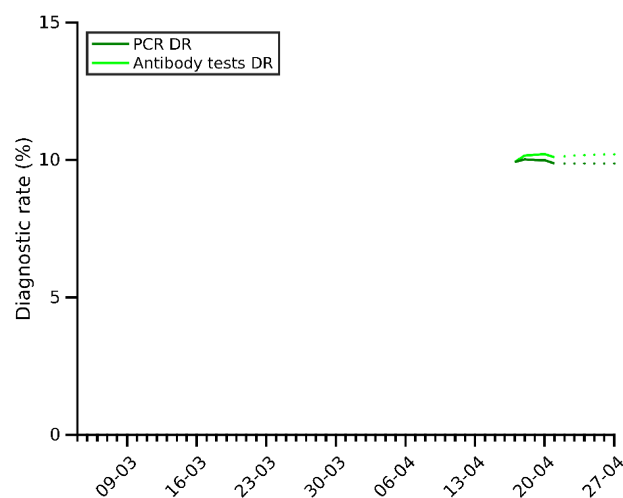
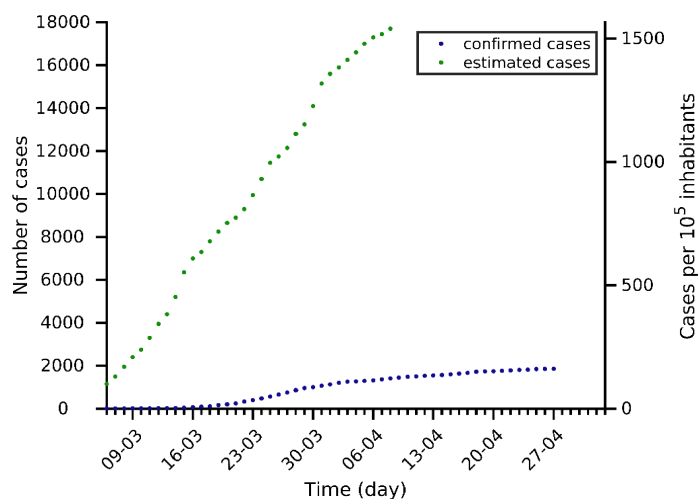
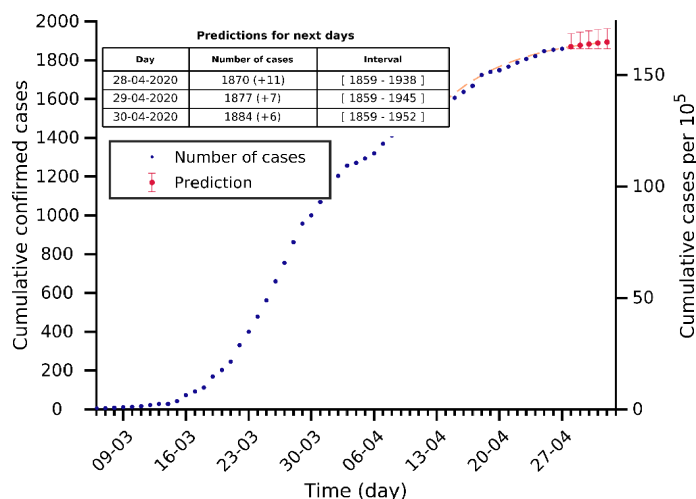
# Canarias 27-04-2020. Population: 2.2M. Current cumulated incidence: 101/10<sup>5</sup>



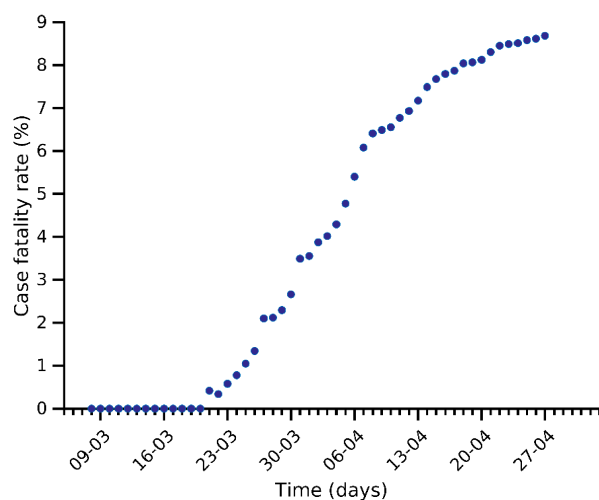
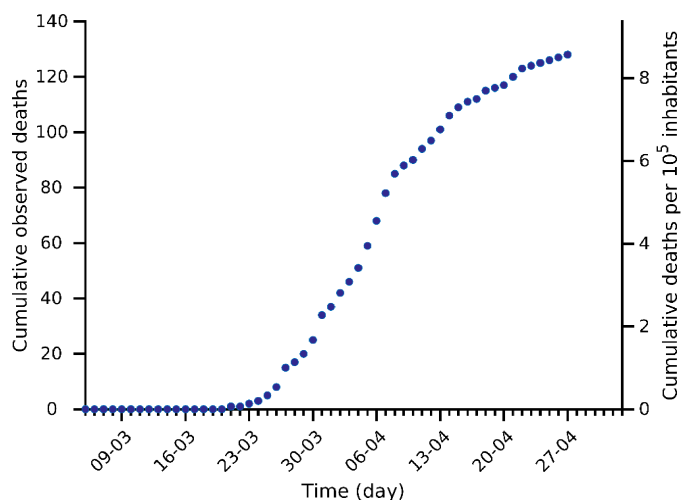
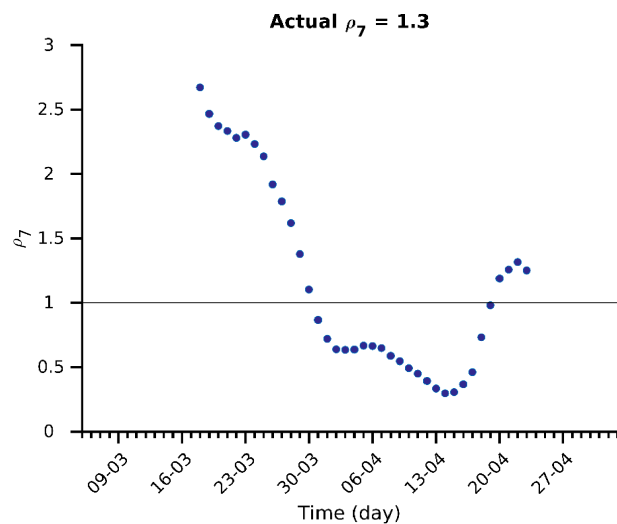
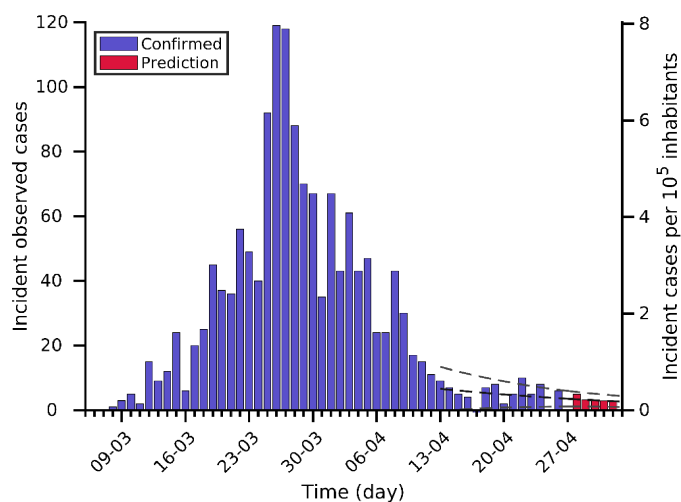
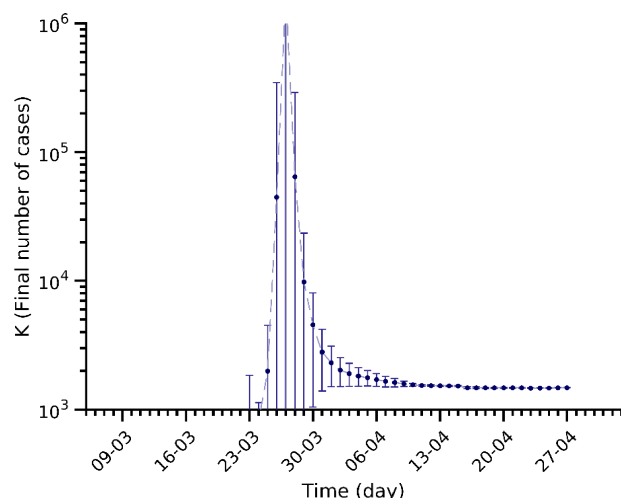
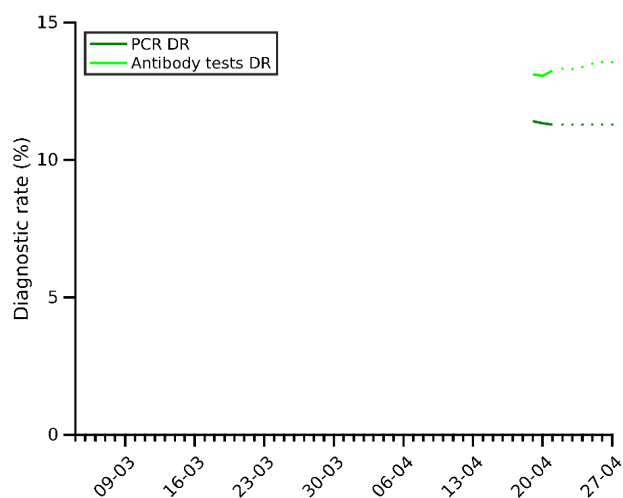
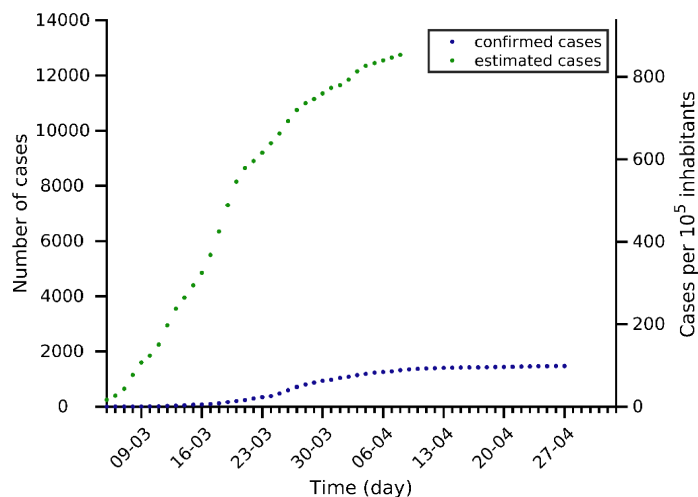
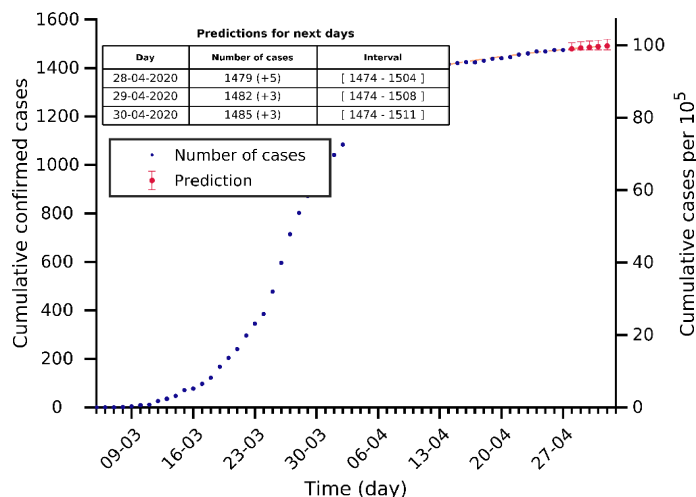
# Cantabria 27-04-2020. Population: 0.6M. Current cumulated incidence: 362/10<sup>5</sup>



# Baleares 27-04-2020. Population: 1.1M. Current cumulated incidence: 162/10<sup>5</sup>



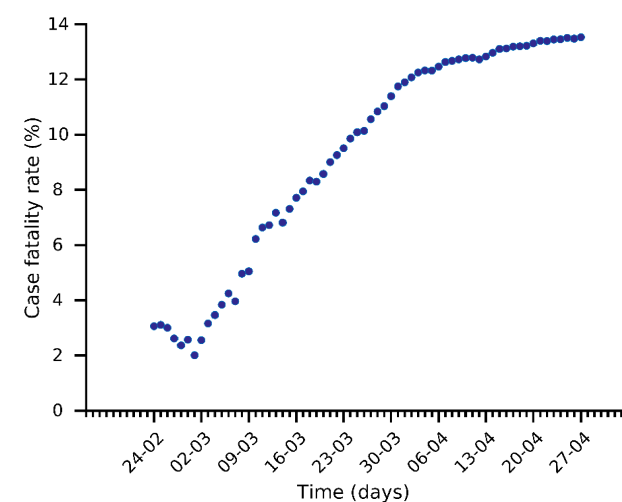
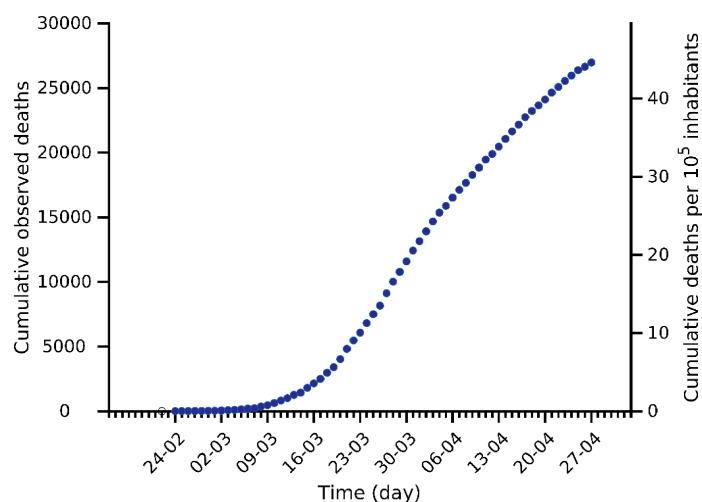
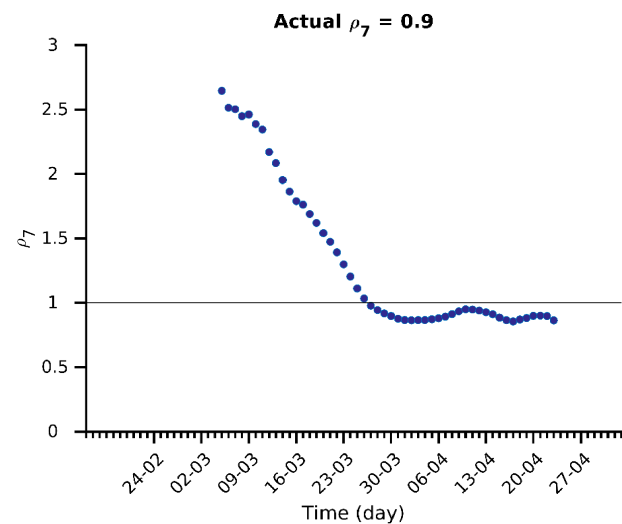
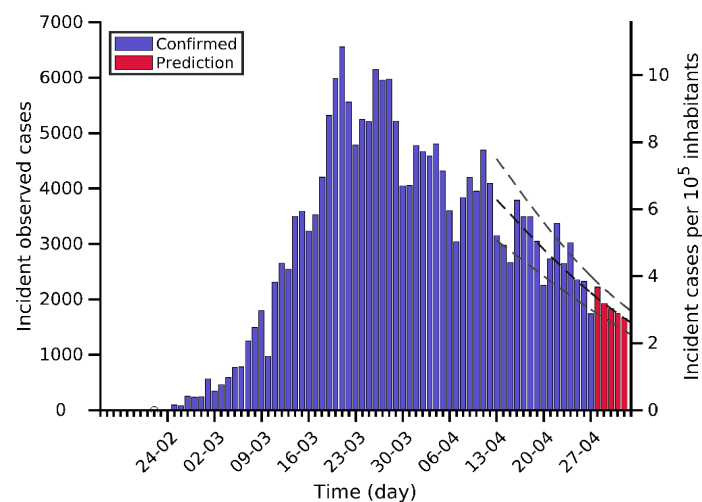
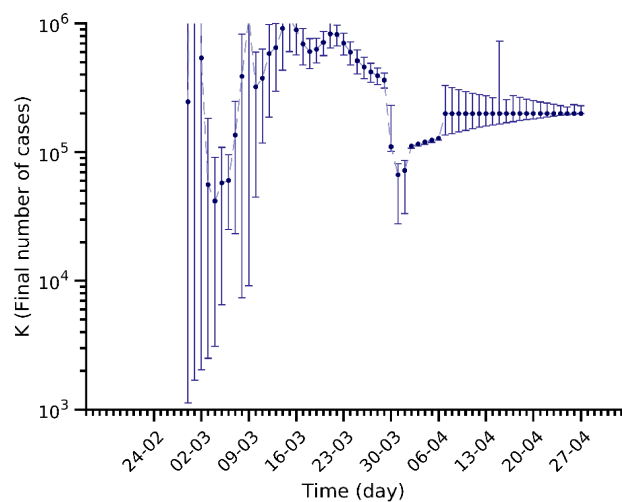
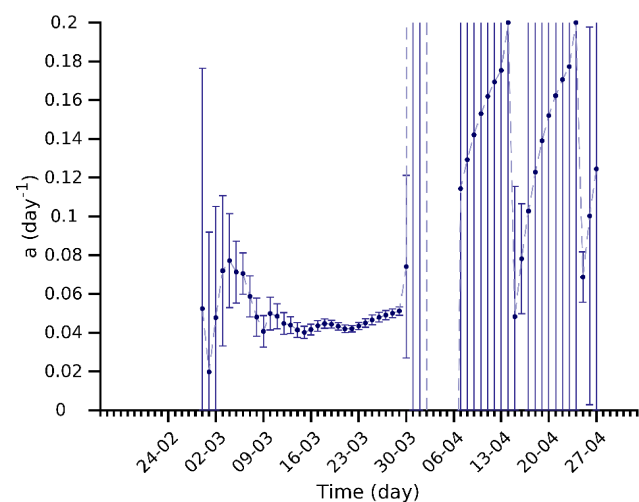
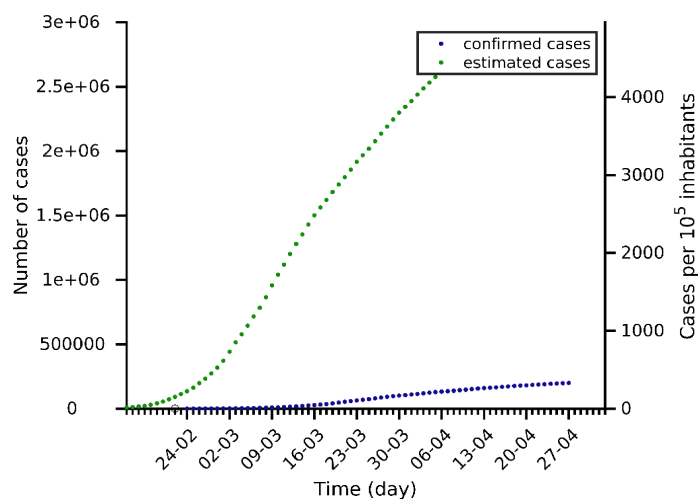
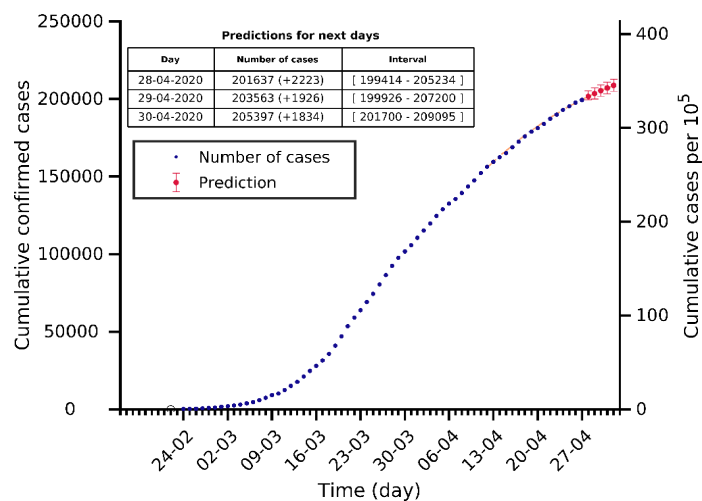
# Murcia 27-04-2020. Population: 1.5M. Current cumulated incidence: 99/10<sup>5</sup>



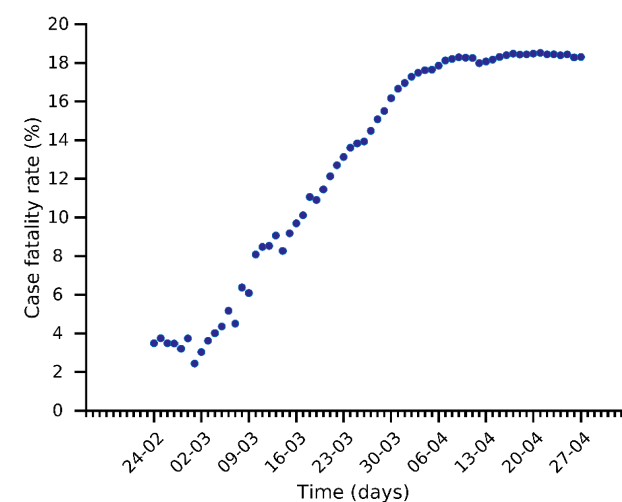
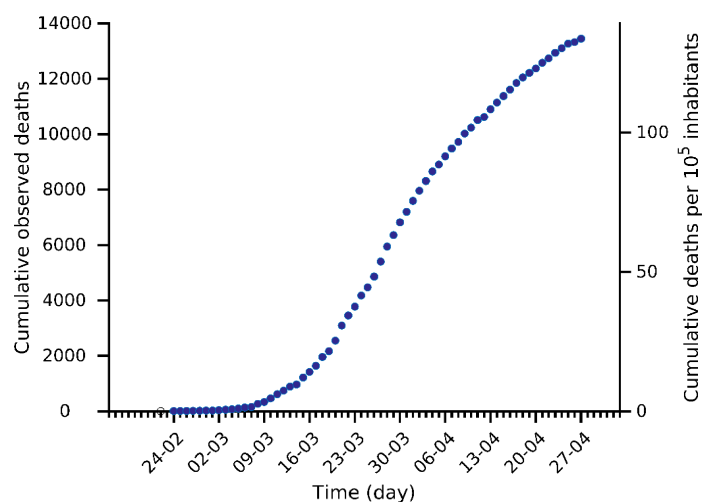
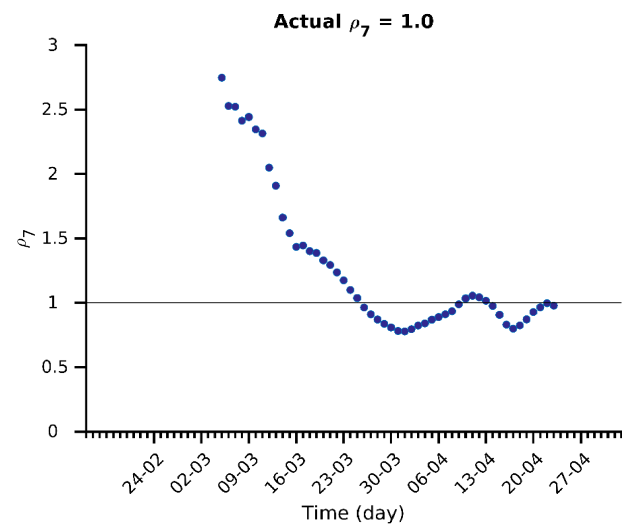
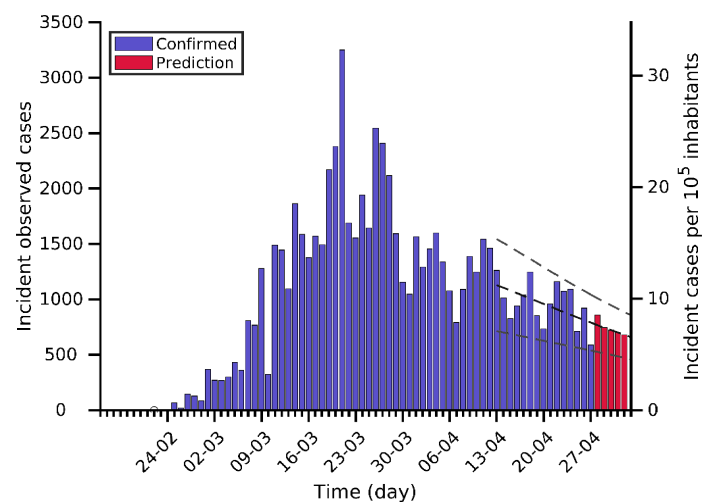
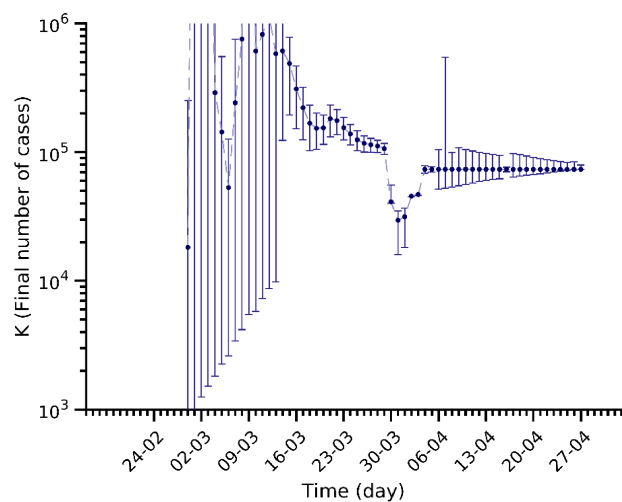
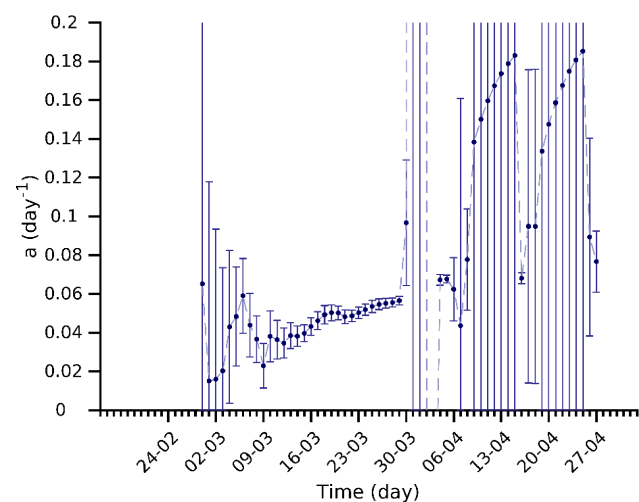
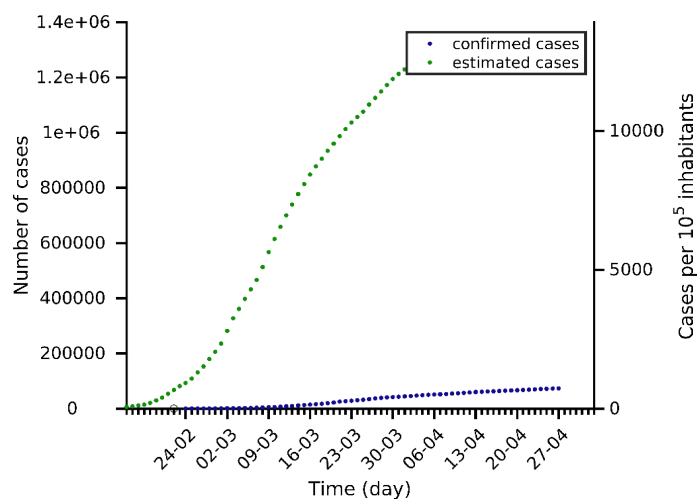
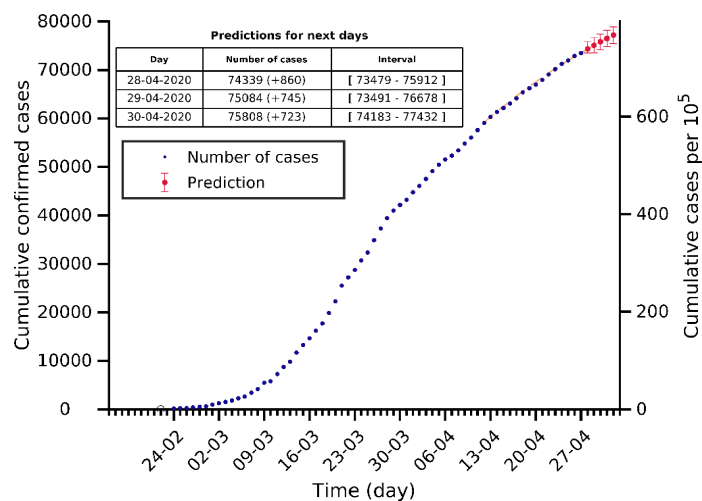
## **(4) Analysis and prediction of COVID-19 for Italy and its regions**

Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

# Italy 27-04-2020. Population: 60.5M. Current cumulated incidence: 330/10<sup>5</sup>

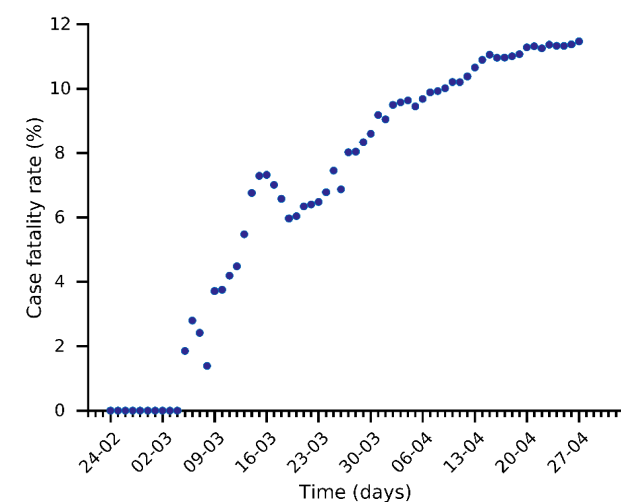
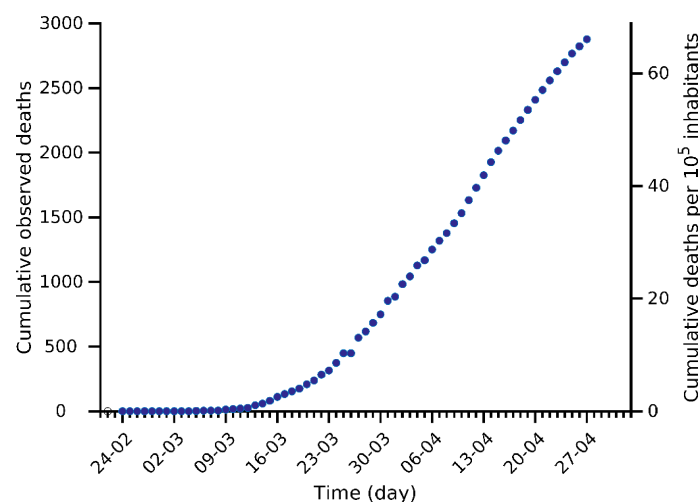
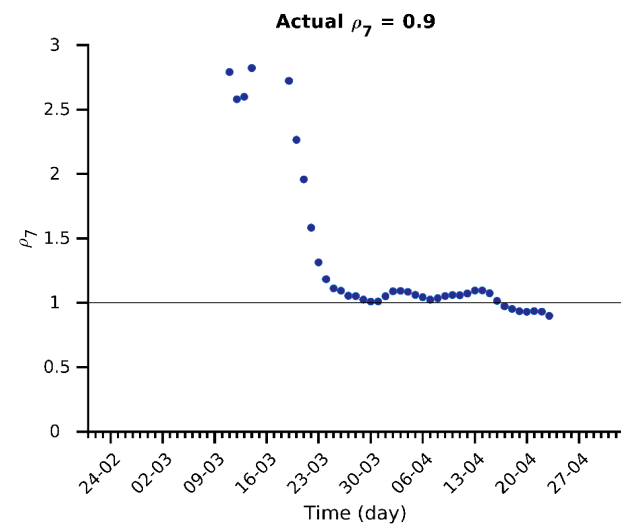
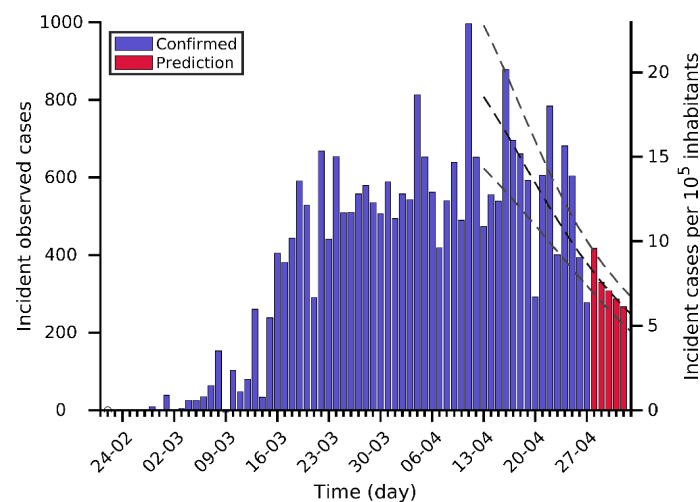
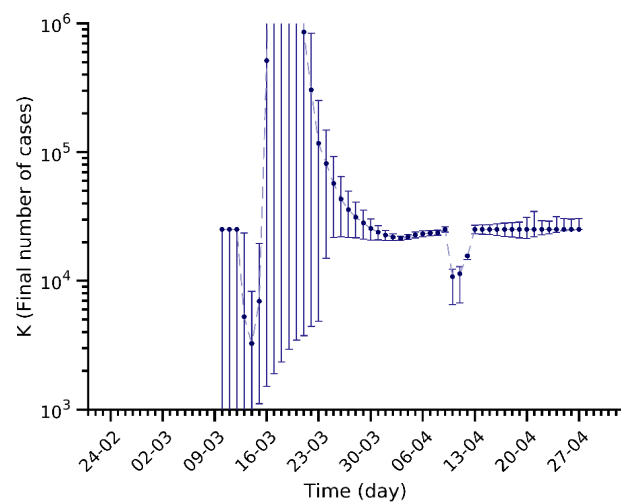
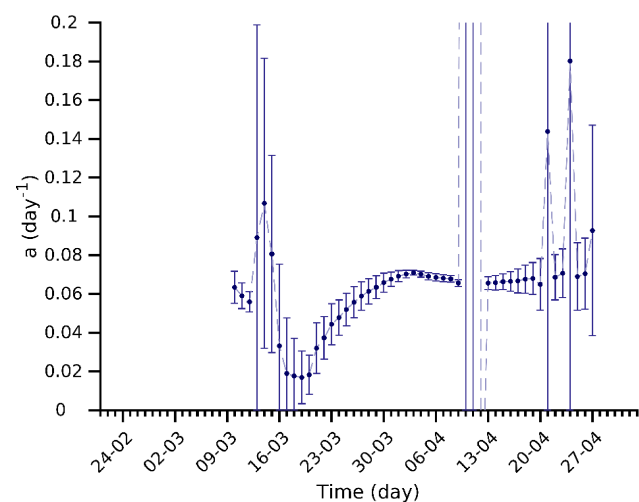
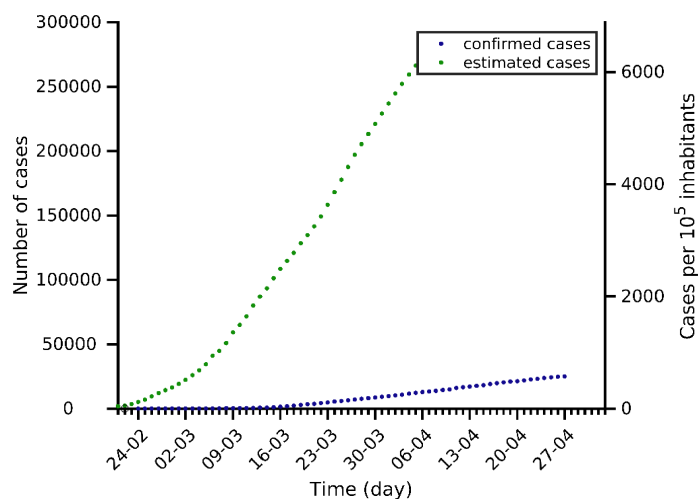
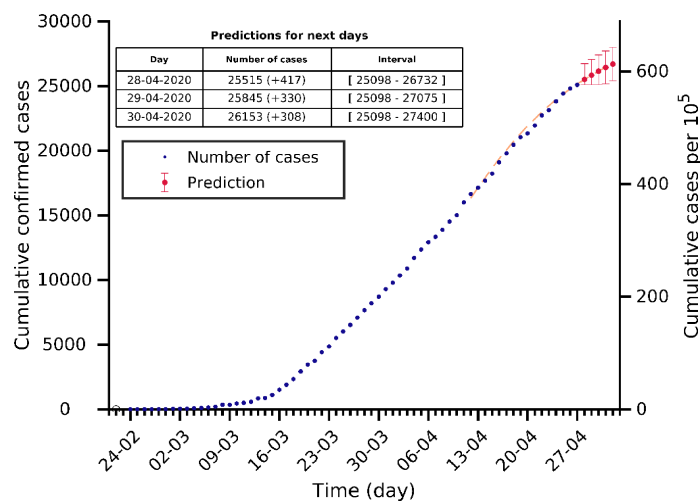


# Lombardia 27-04-2020. Population: 10.1M. Current cumulated incidence: 730/10<sup>5</sup>

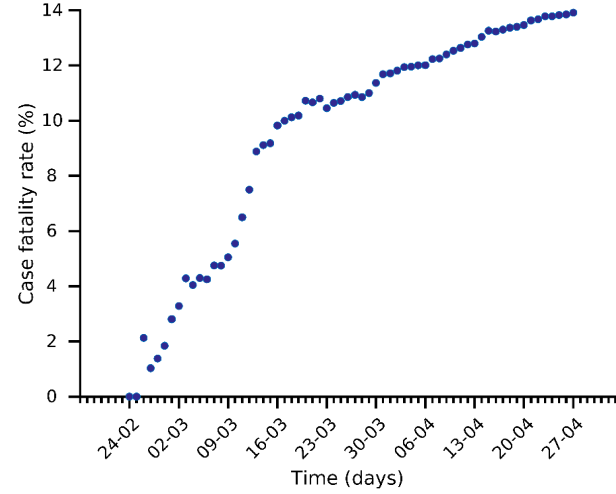
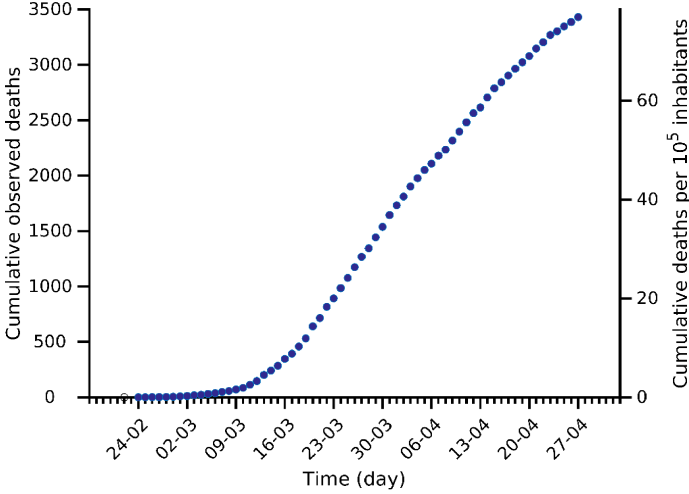
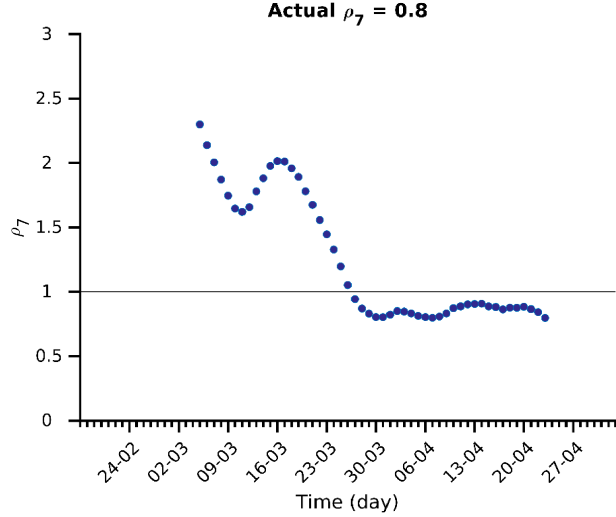
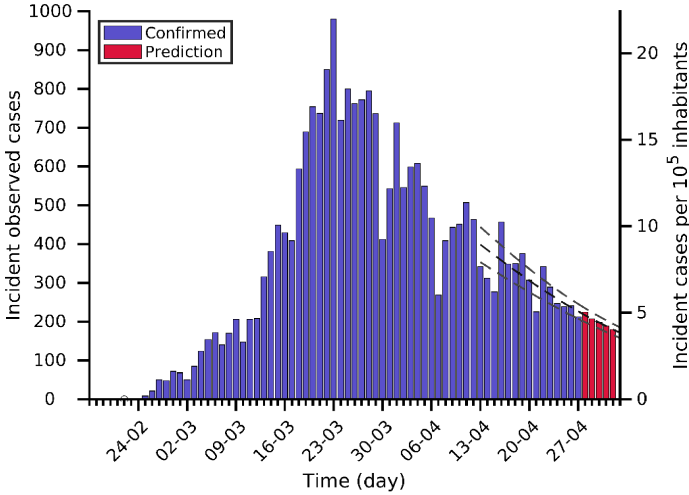
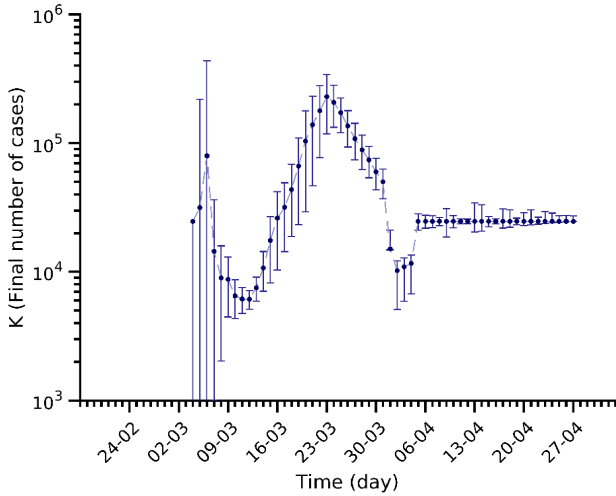
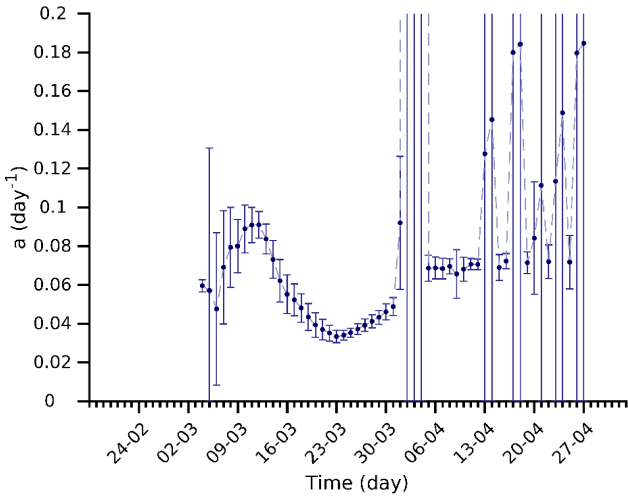
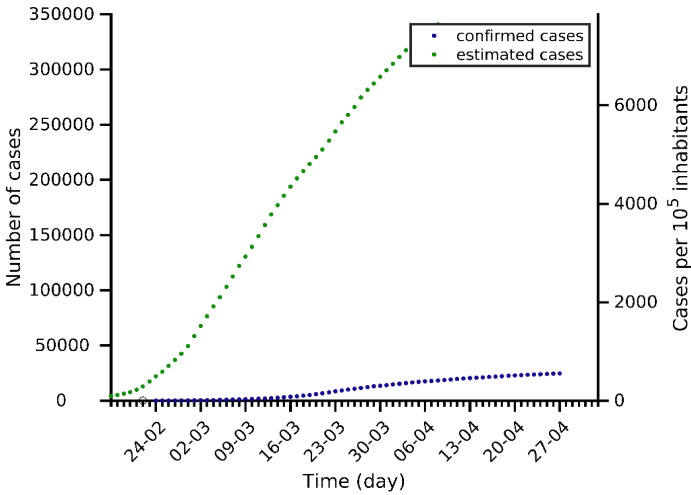
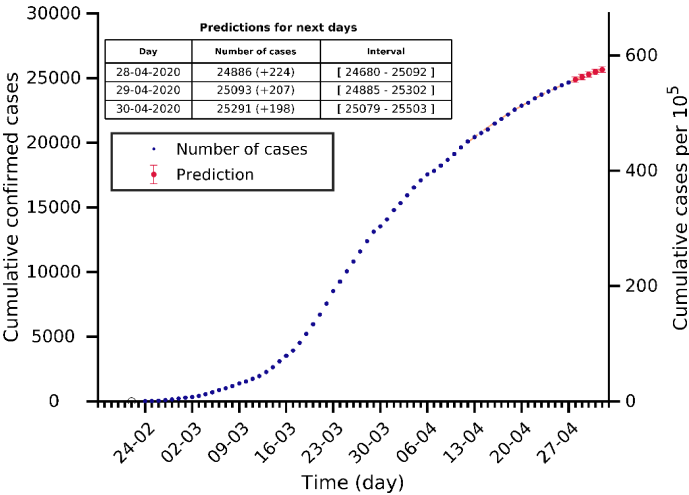




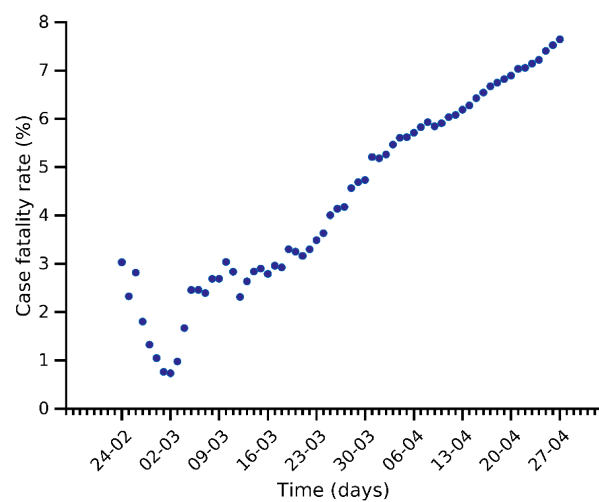
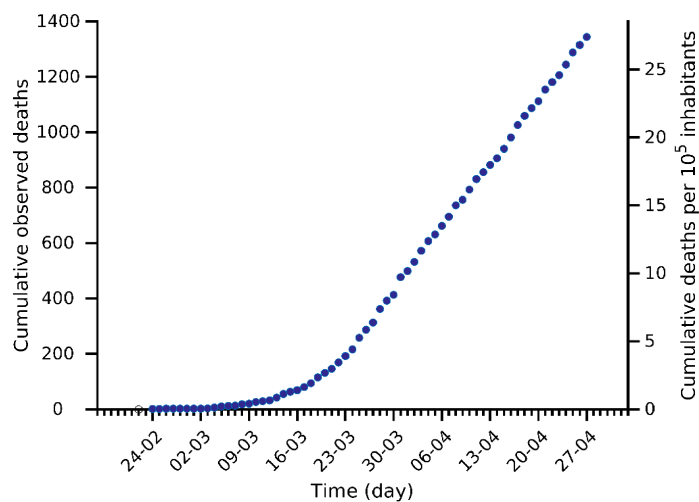
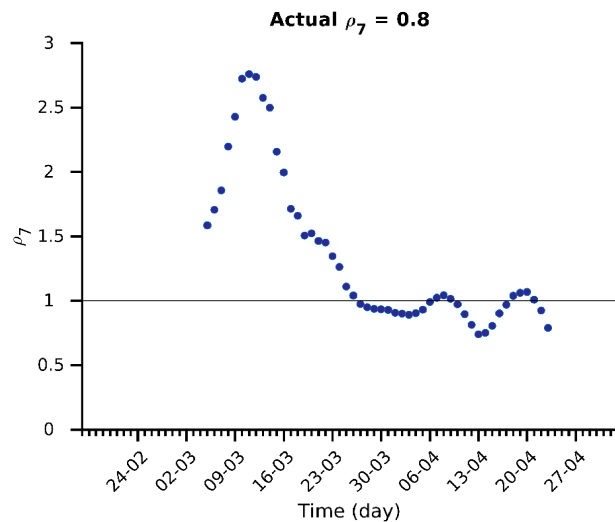
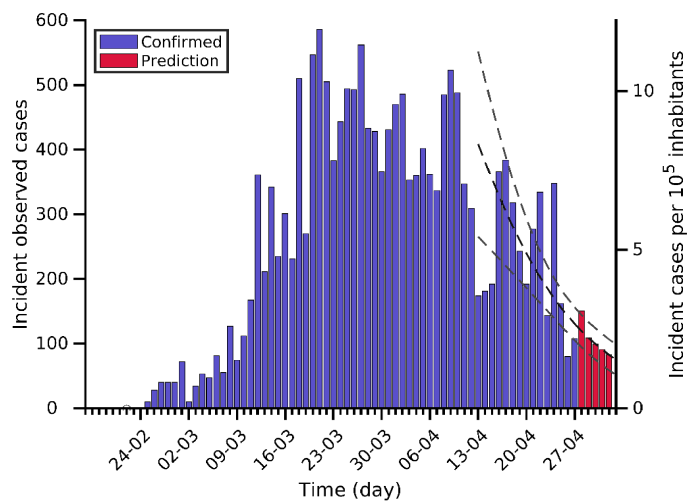
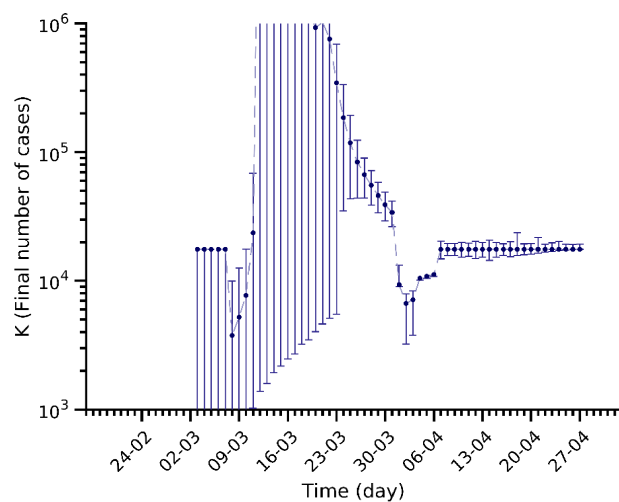
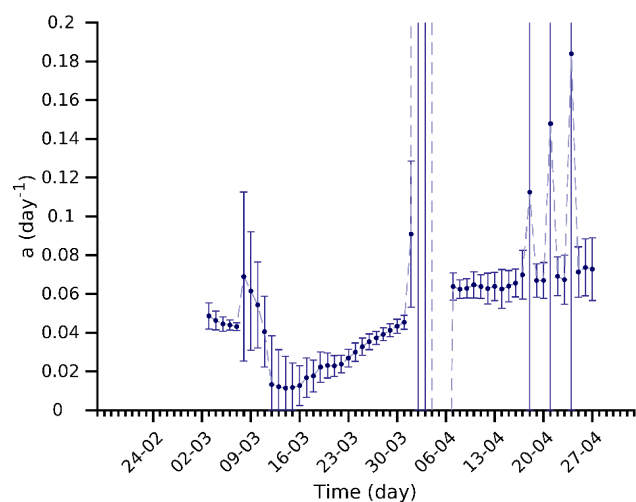
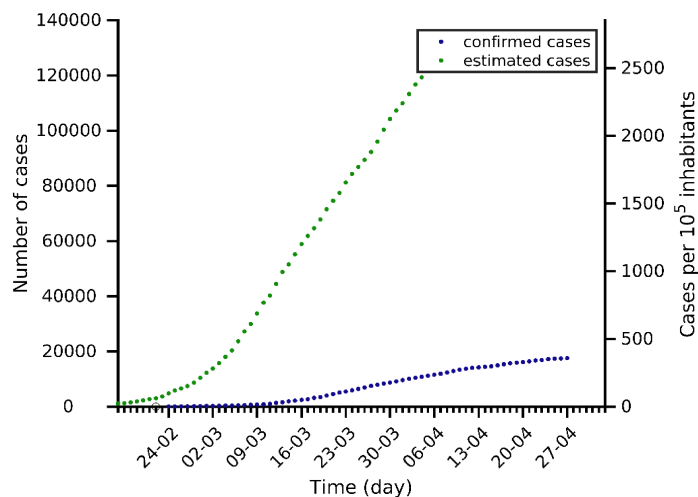
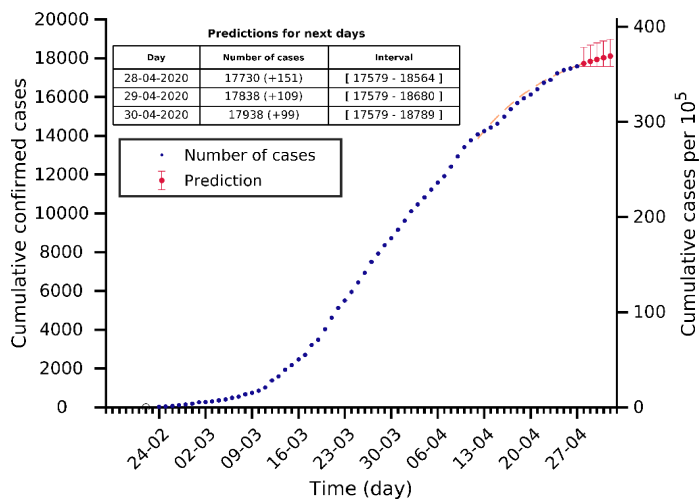
# Piemonte 27-04-2020. Population: 4.4M. Current cumulated incidence: 576/10<sup>5</sup>



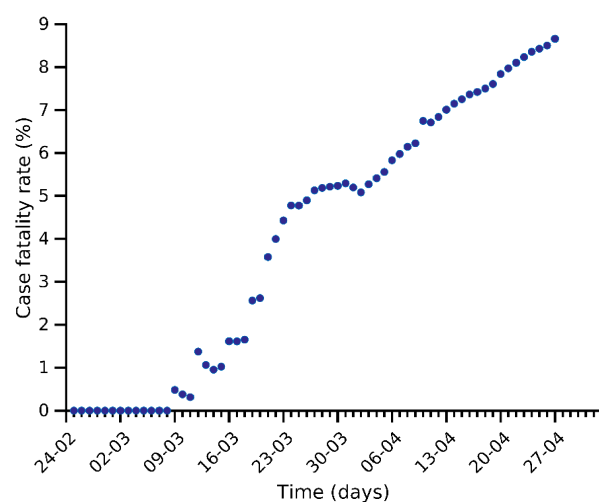
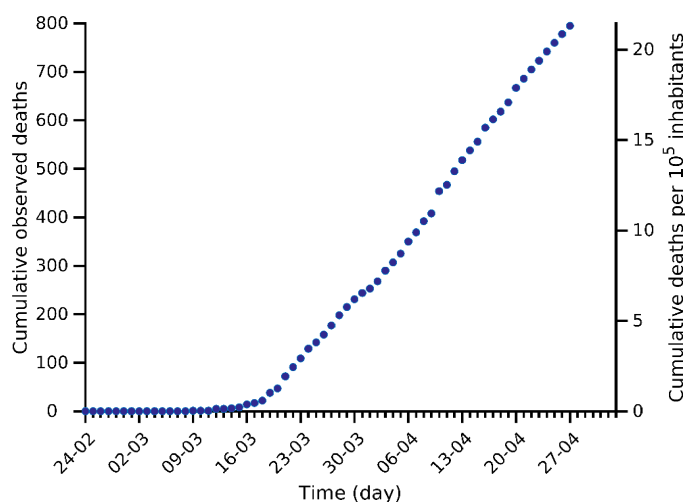
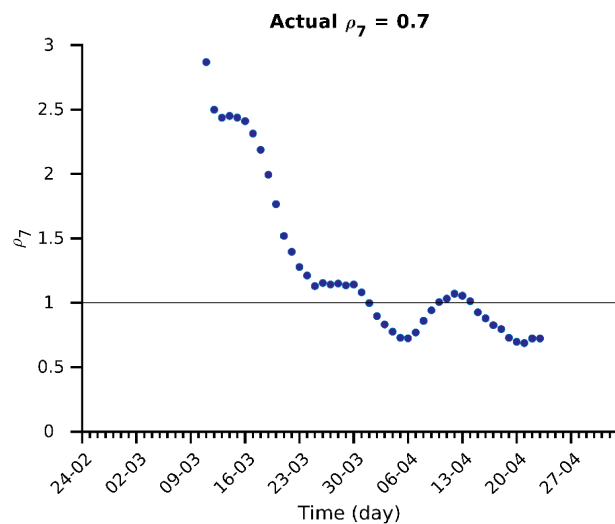
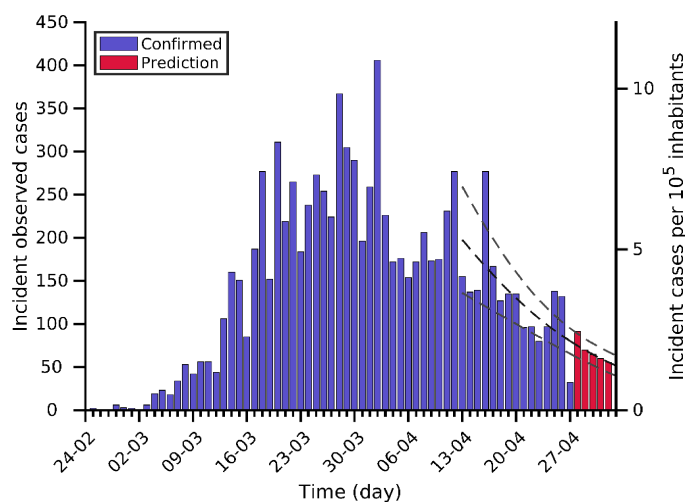
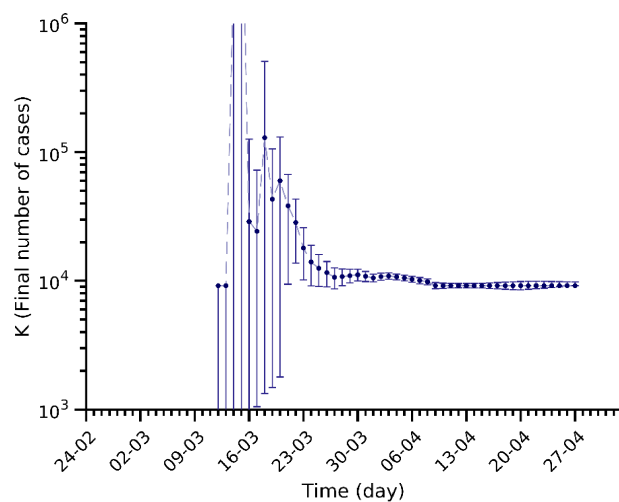
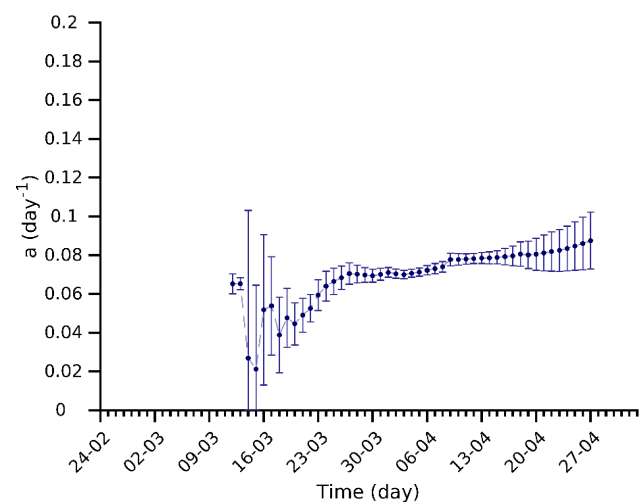
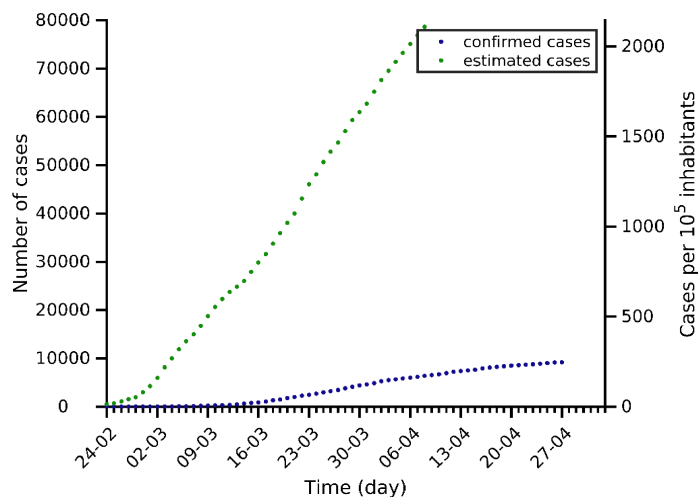
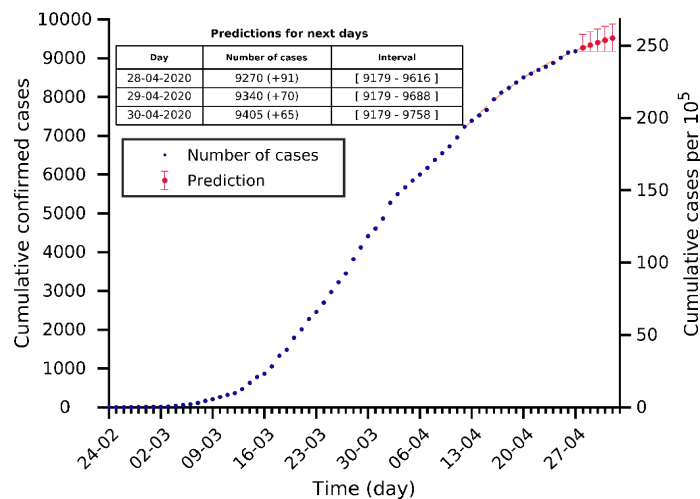
Emilia Romagna 27-04-2020. Population: 4.5M. Current cumulated incidence: 553/100,000



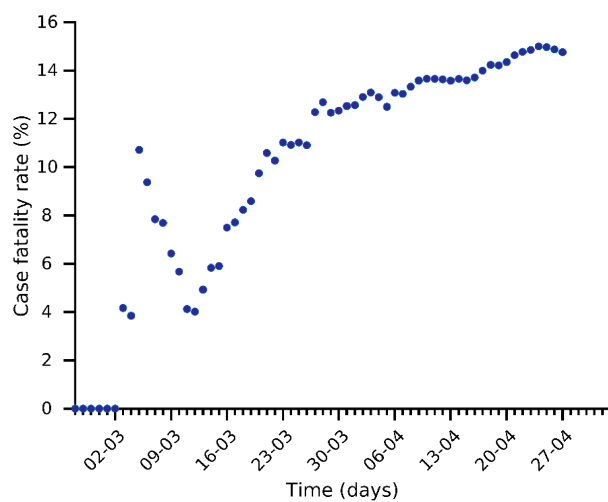
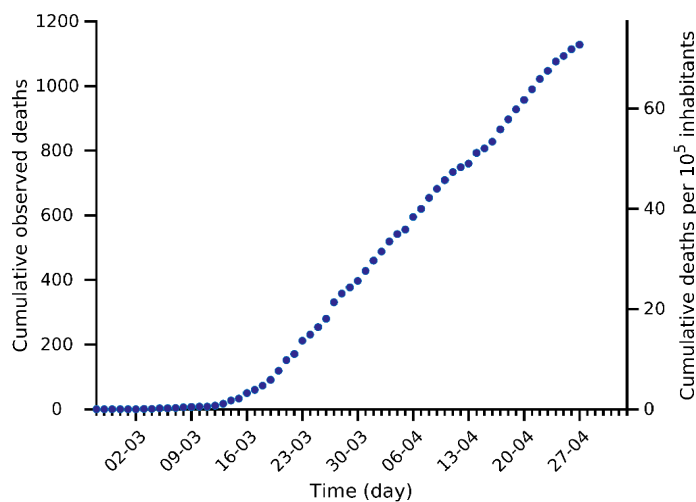
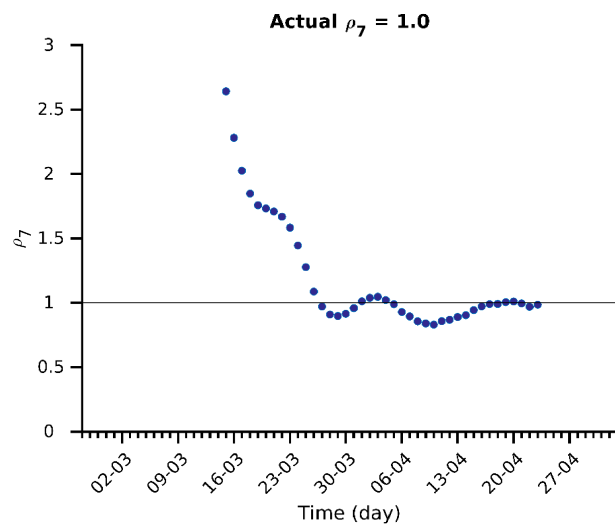
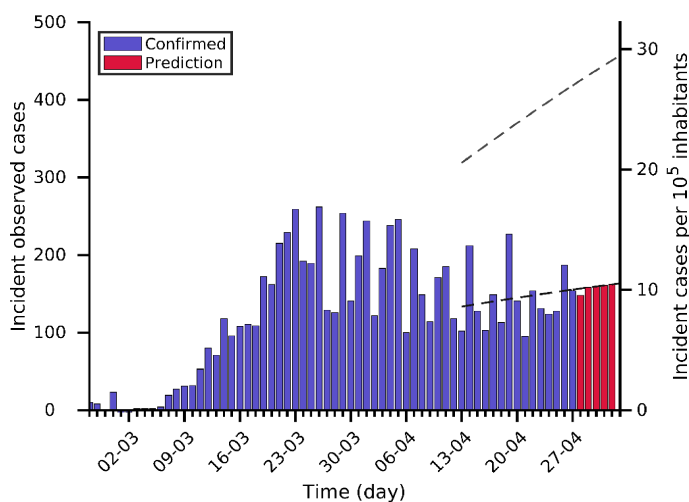
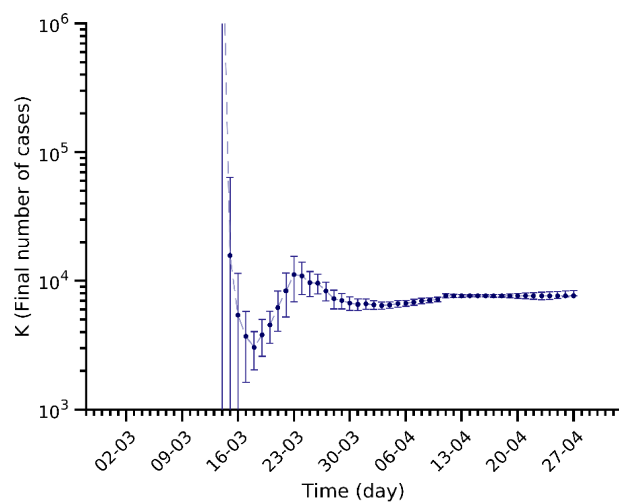
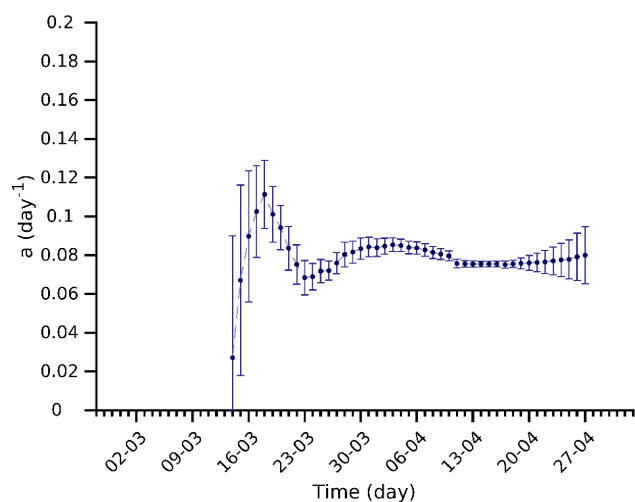
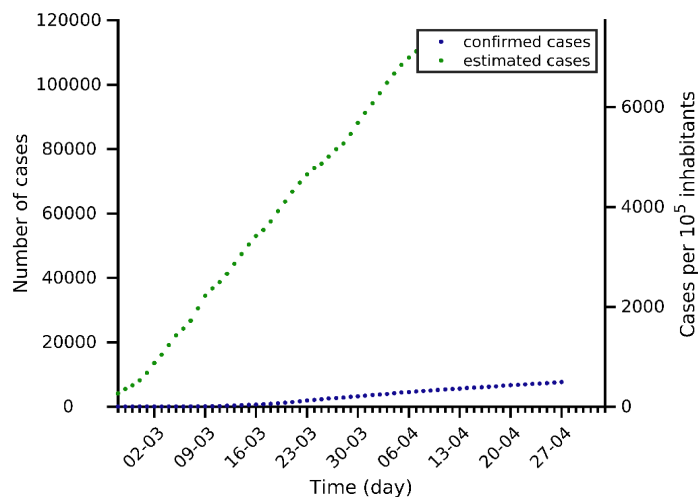
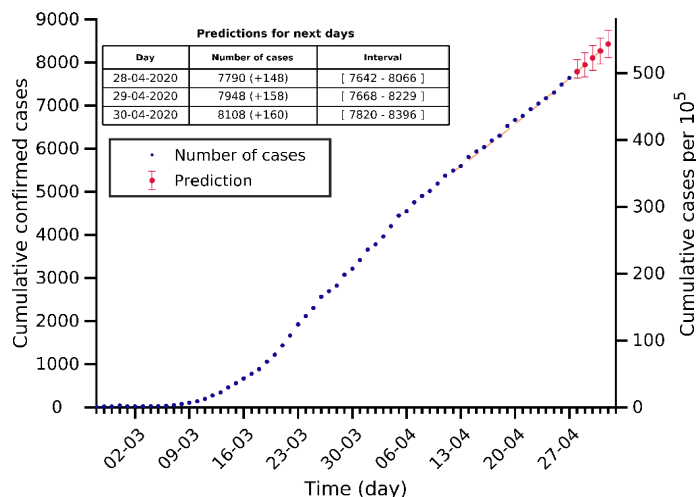
# Veneto 27-04-2020. Population: 4.9M. Current cumulated incidence: 358/10<sup>5</sup>



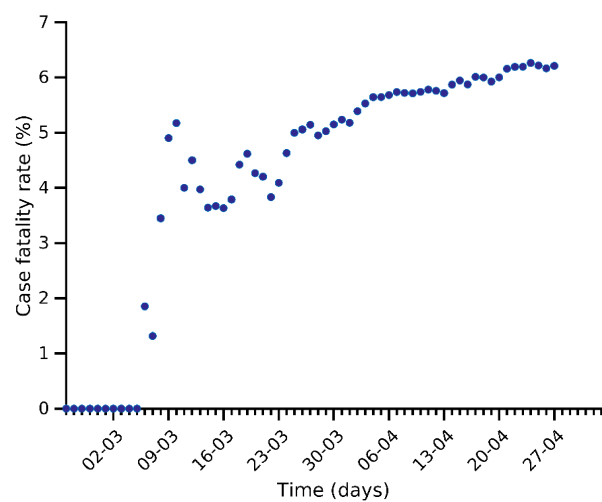
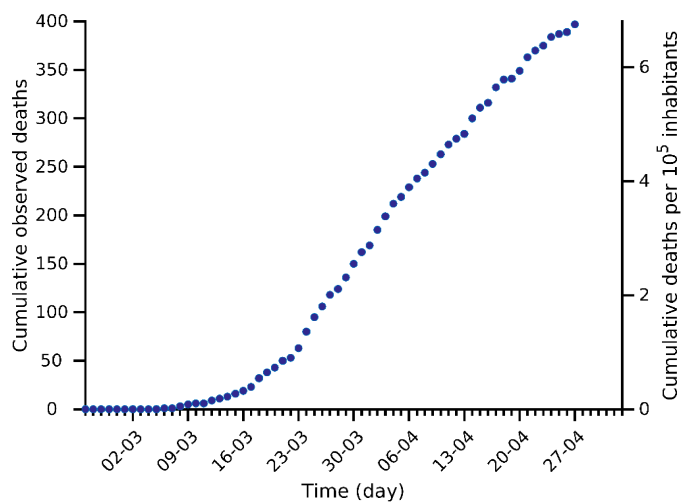
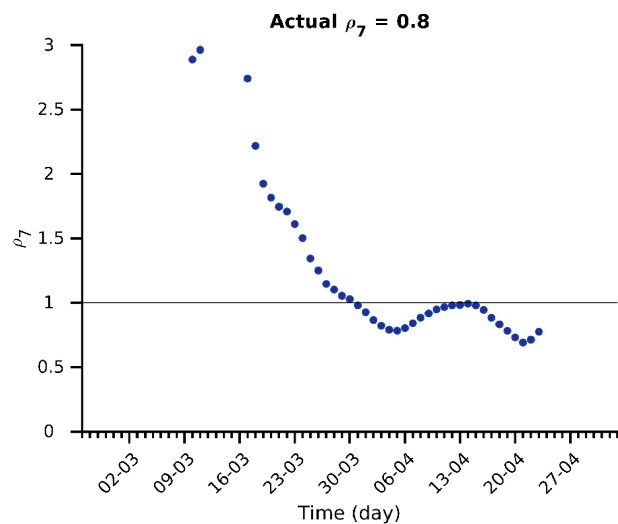
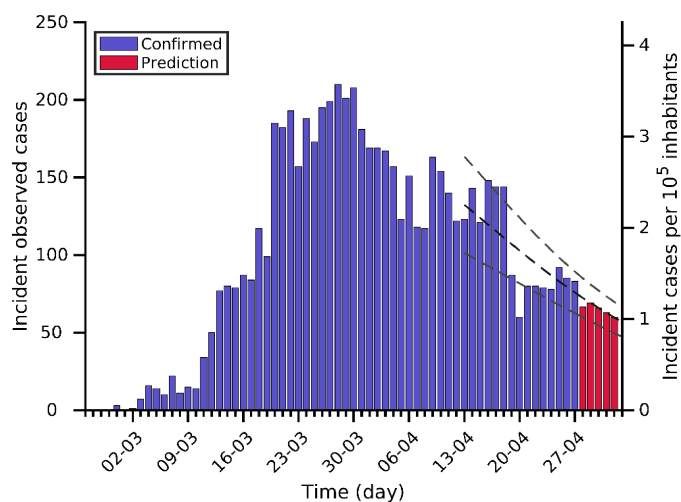
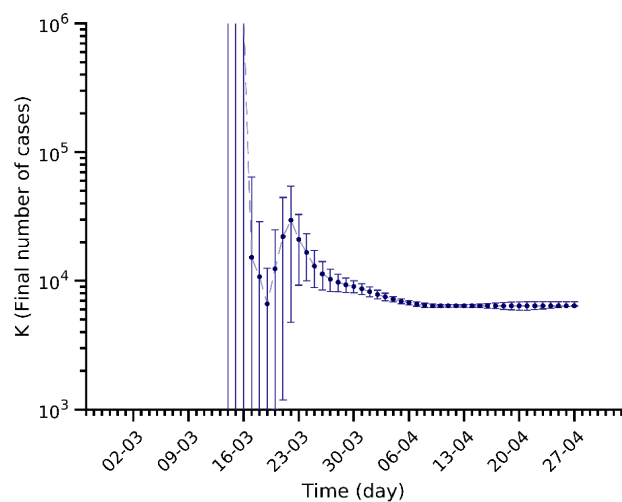
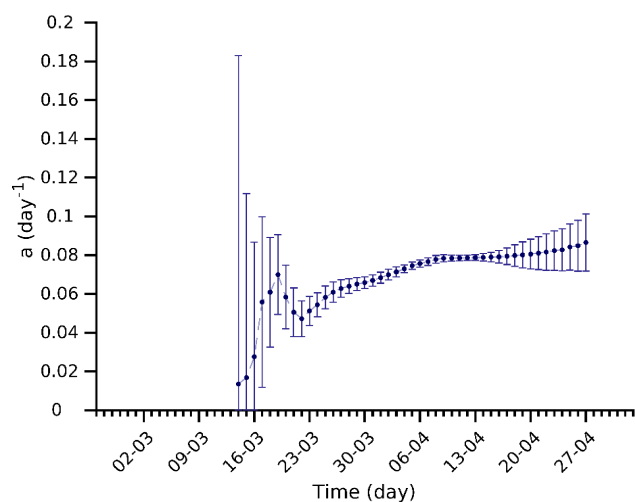
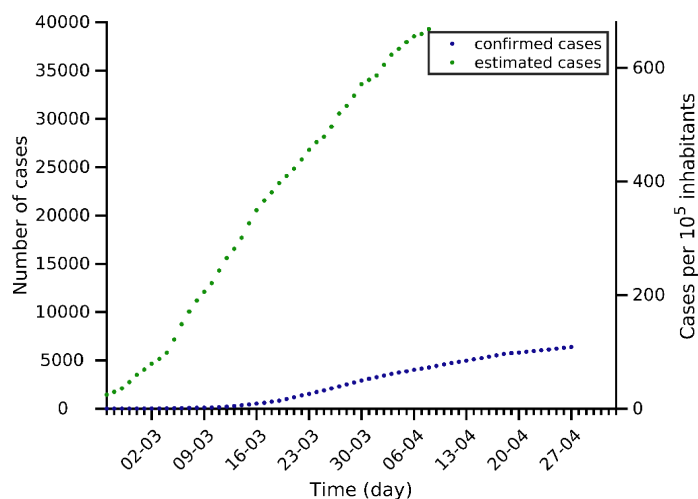
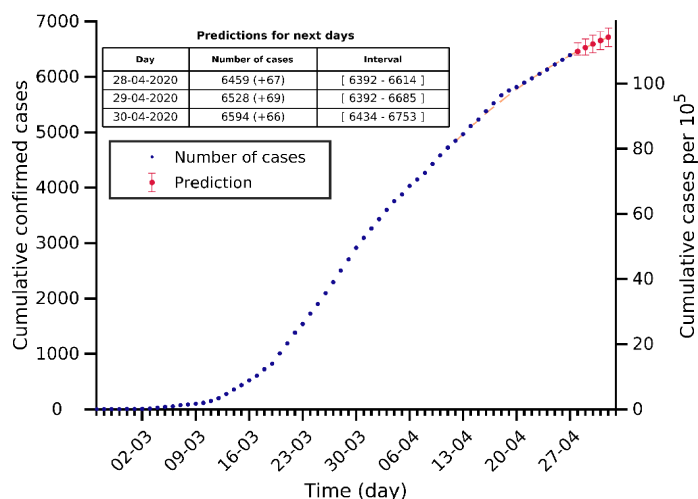
# Toscana 27-04-2020. Population: 3.7M. Current cumulated incidence: 246/10<sup>5</sup>



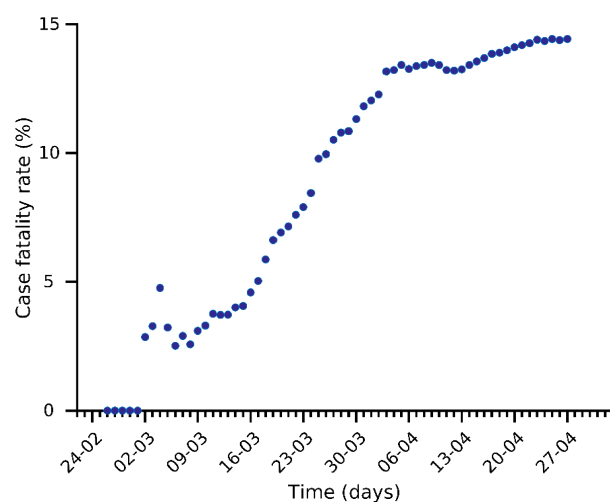
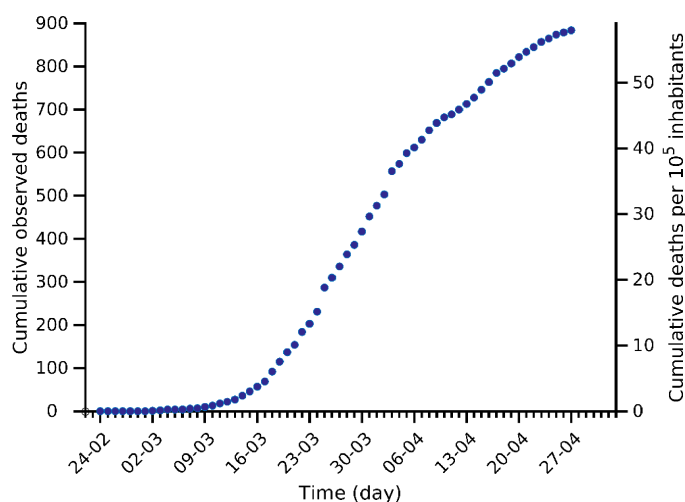
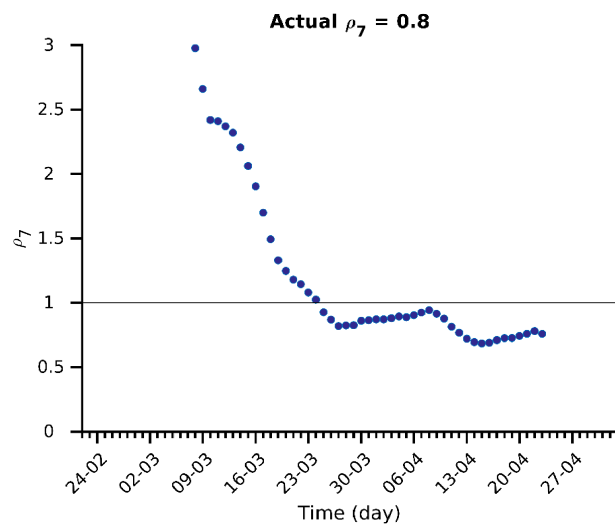
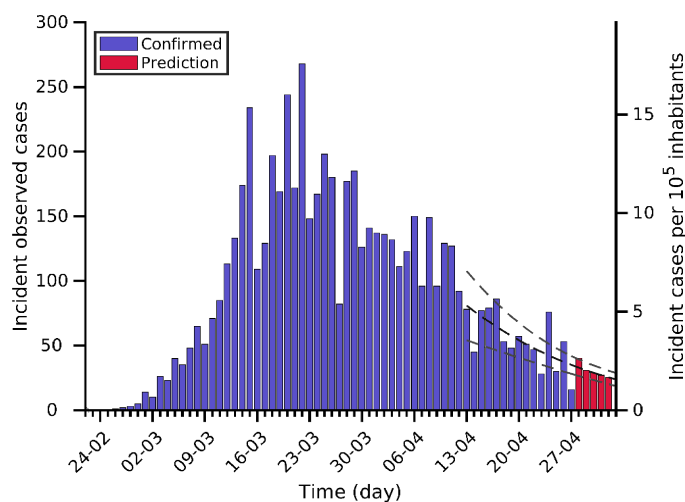
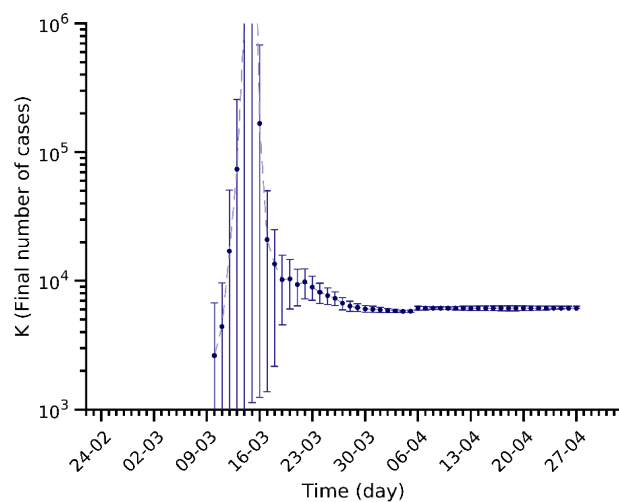
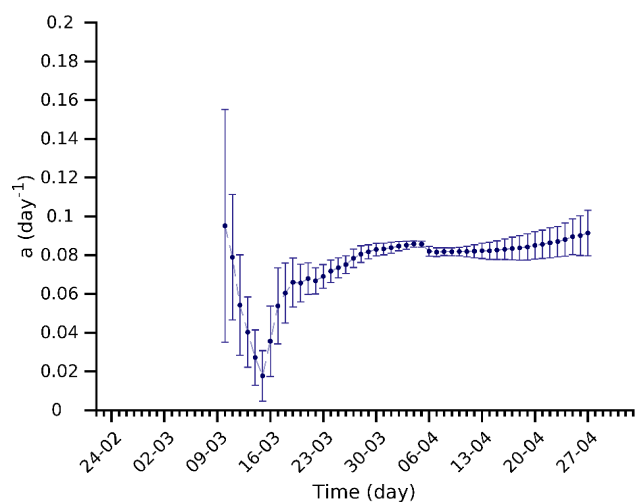
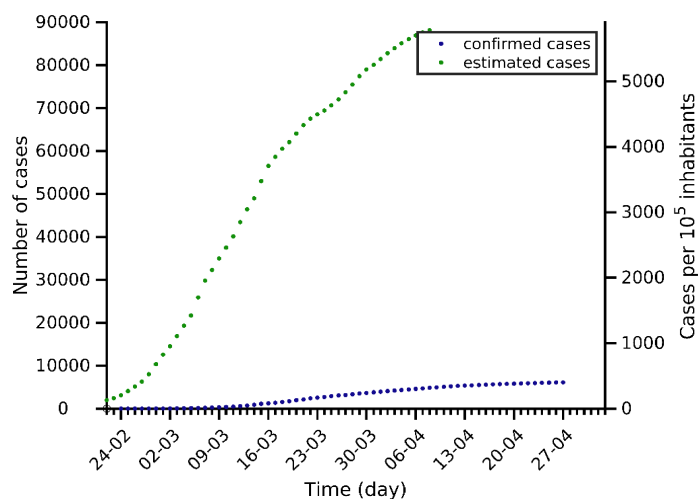
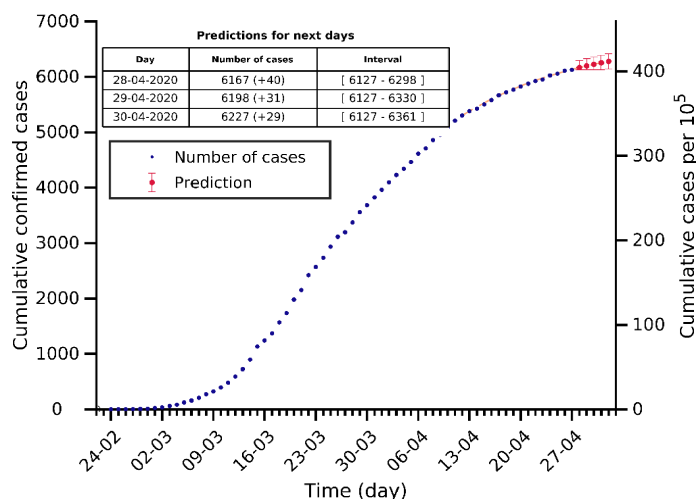
# Liguria 27-04-2020. Population: 1.6M. Current cumulated incidence: 493/10<sup>5</sup>



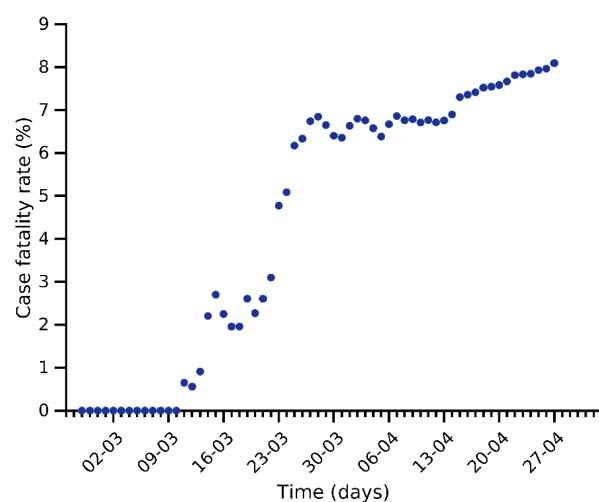
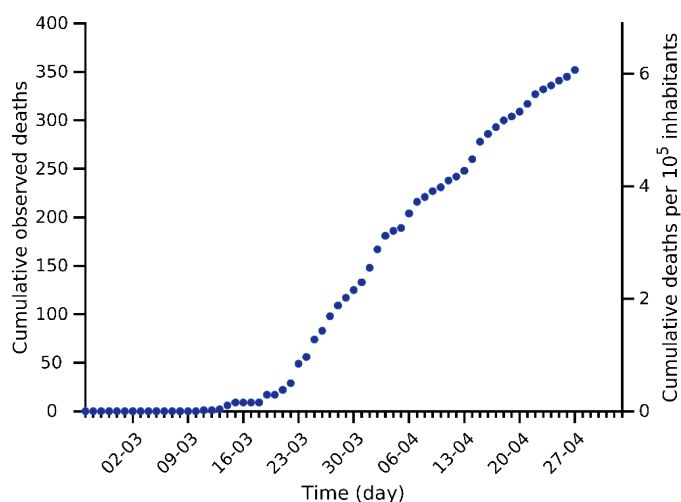
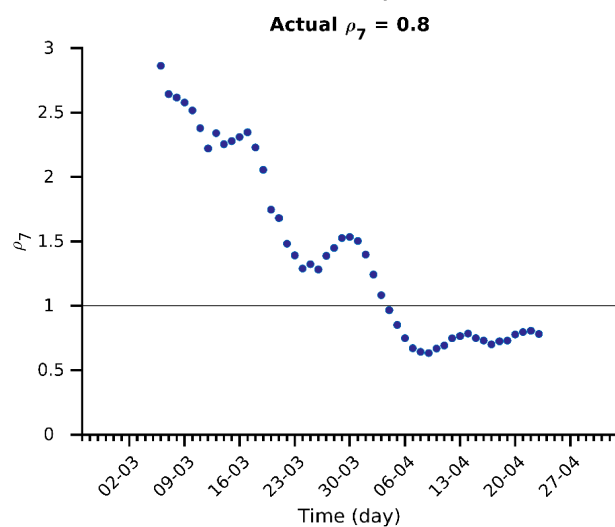
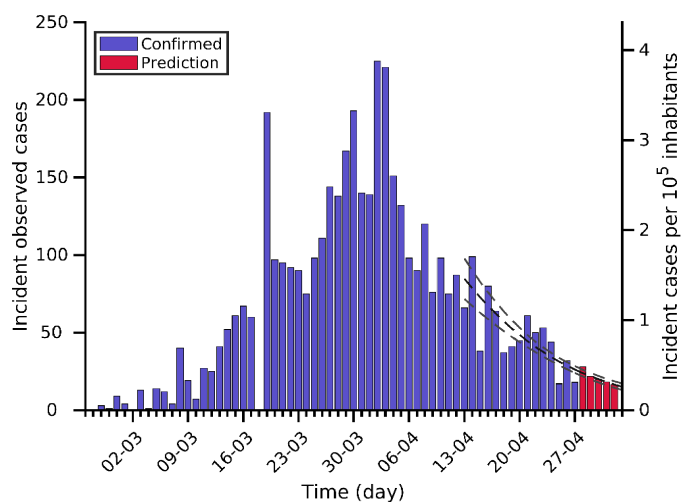
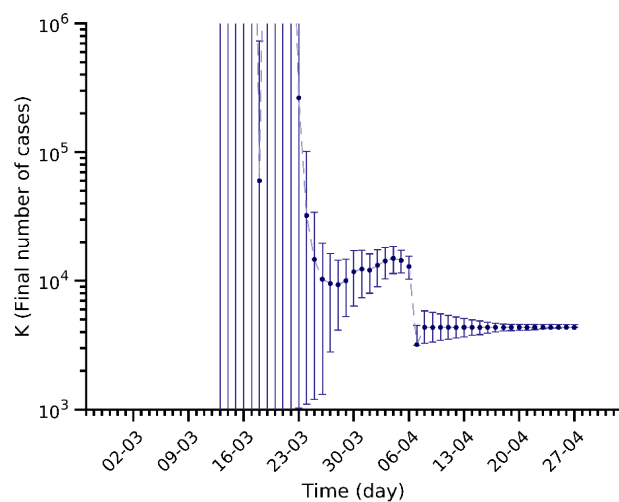
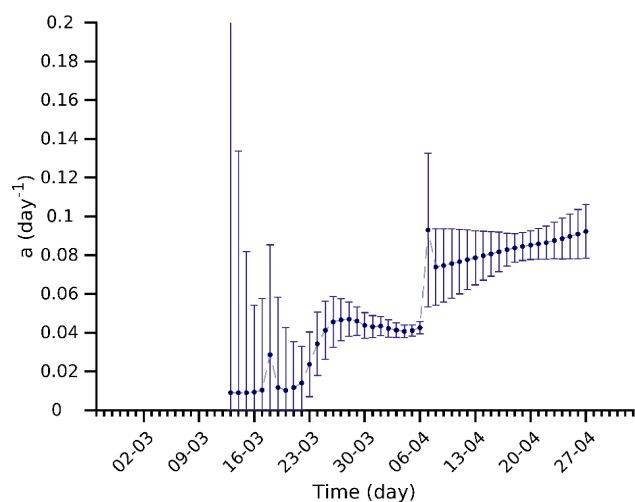
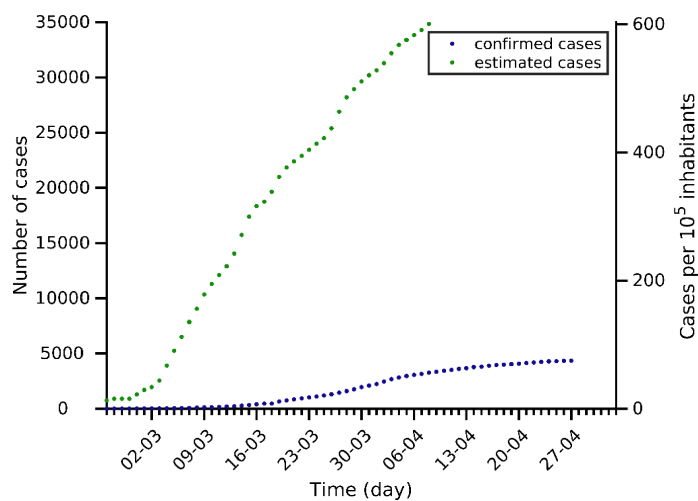
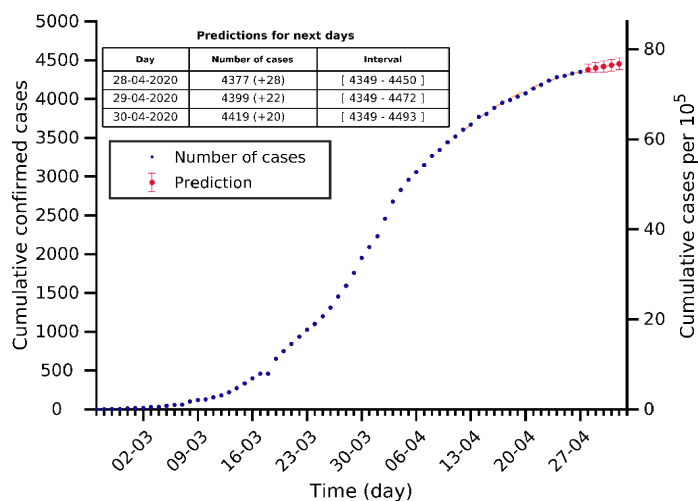
# Lazio 27-04-2020. Population: 5.9M. Current cumulated incidence: 109/10<sup>5</sup>



# **Marche 27-04-2020. Population: 1.5M. Current cumulated incidence: 402/10<sup>5</sup>**

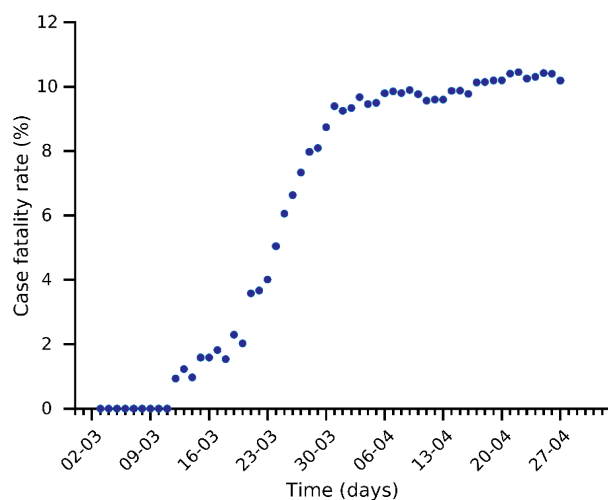
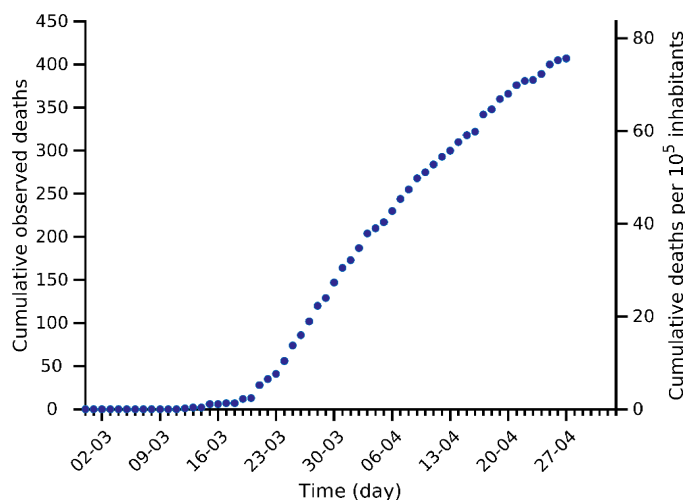
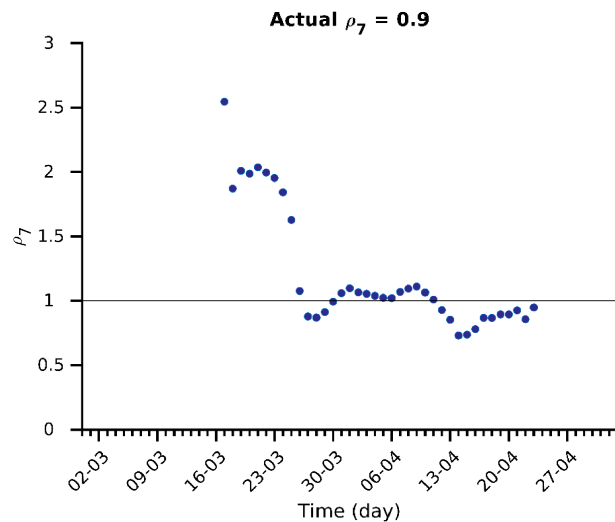
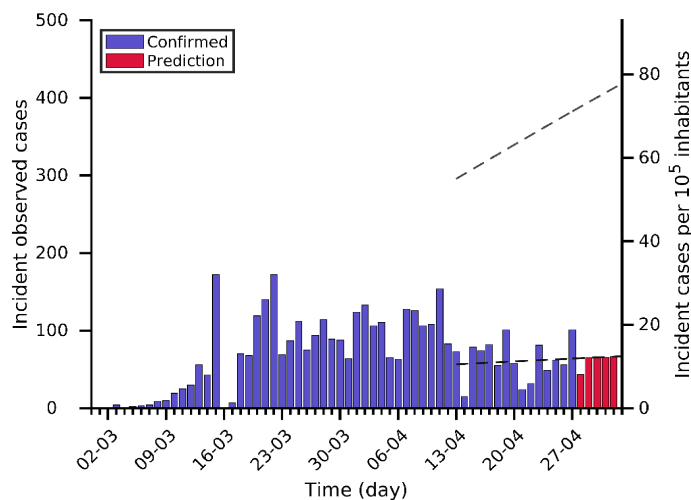
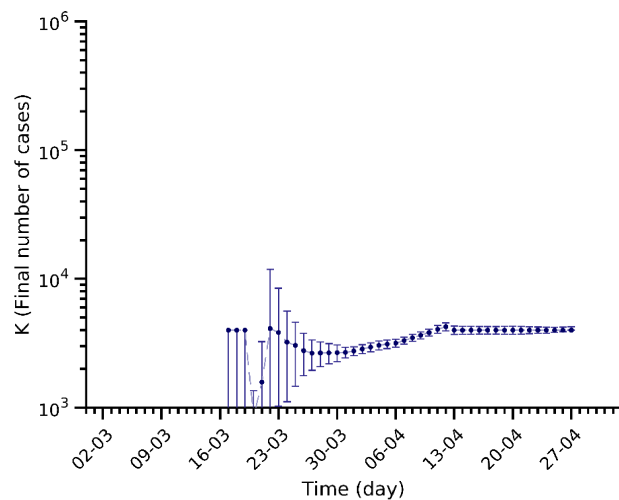
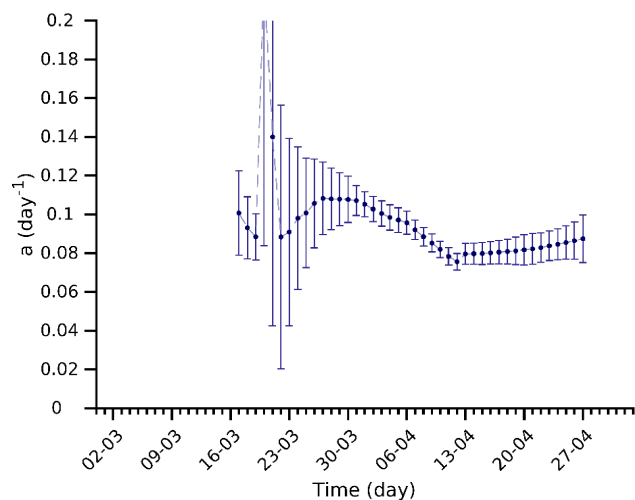
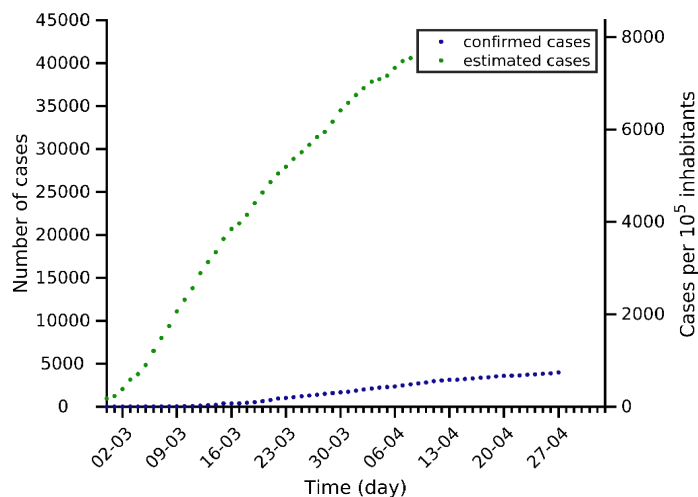
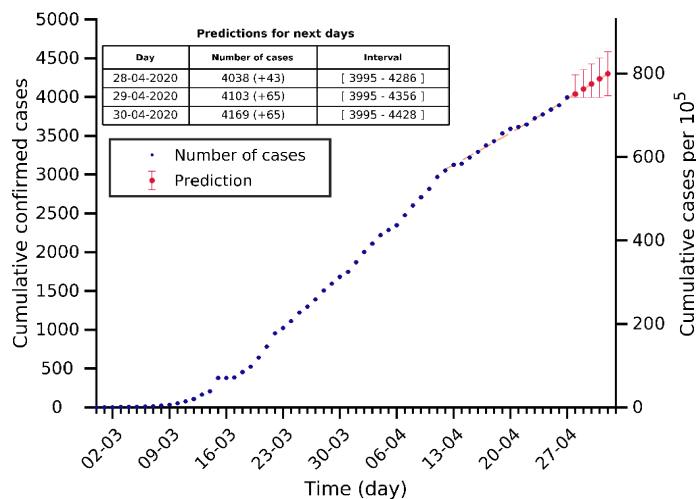


# Campania 27-04-2020. Population: 5.8M. Current cumulated incidence: 75/10<sup>5</sup>

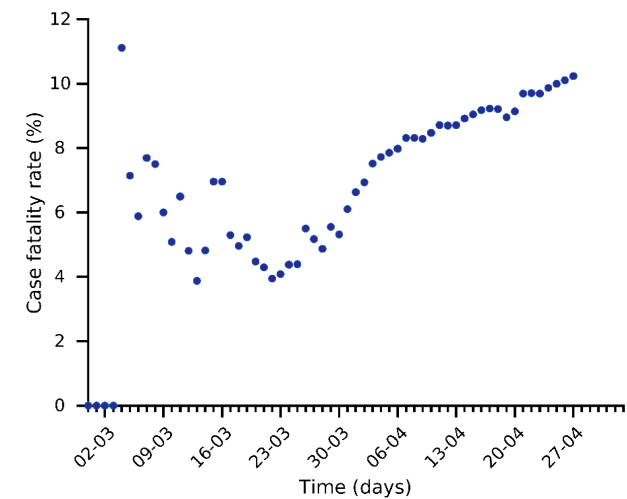
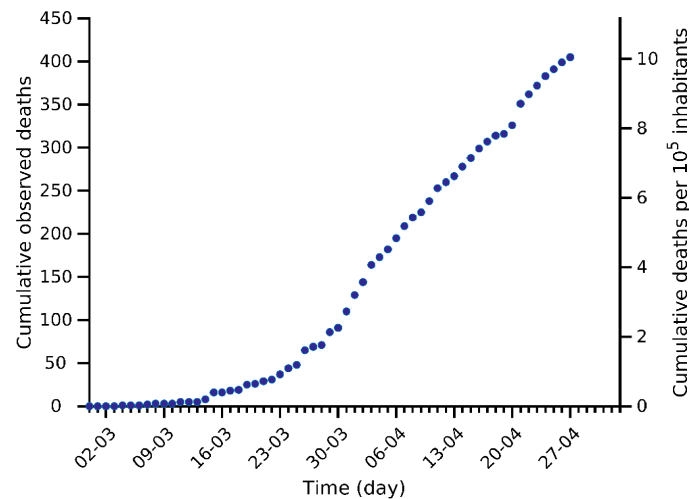
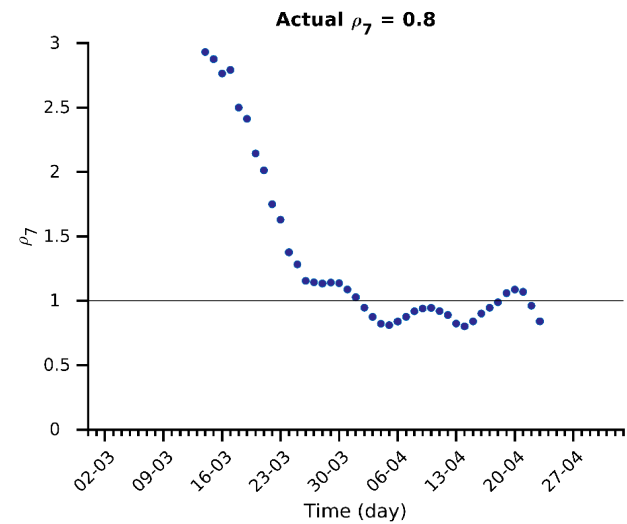
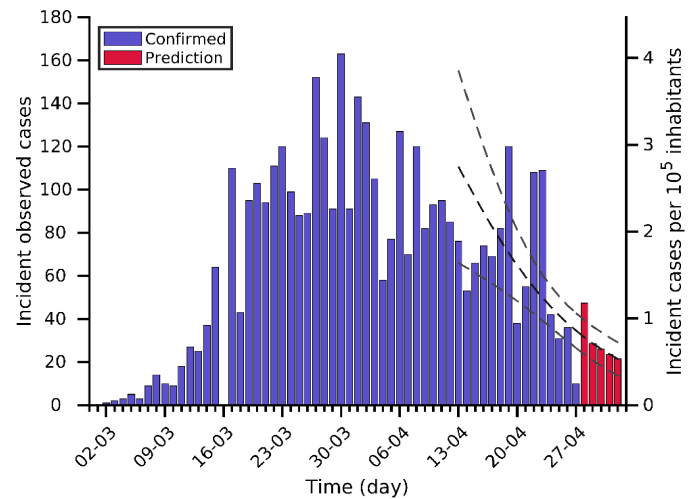
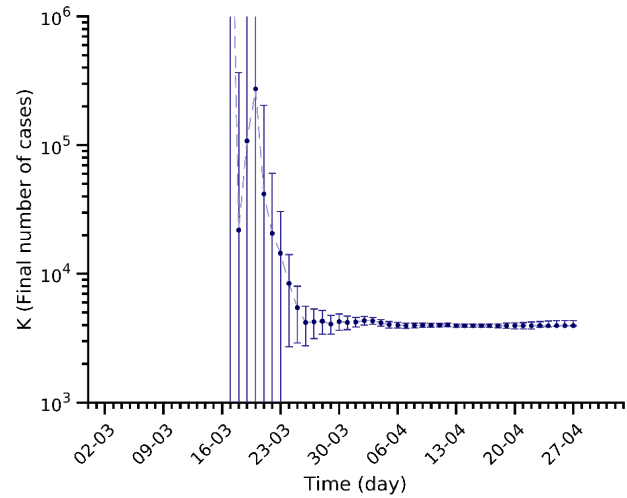
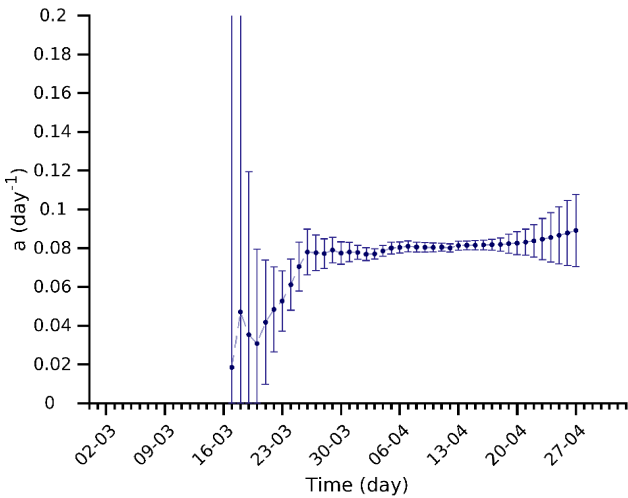
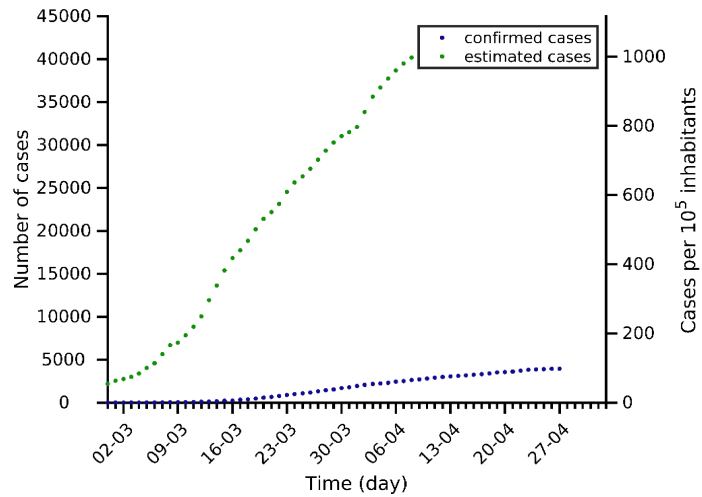
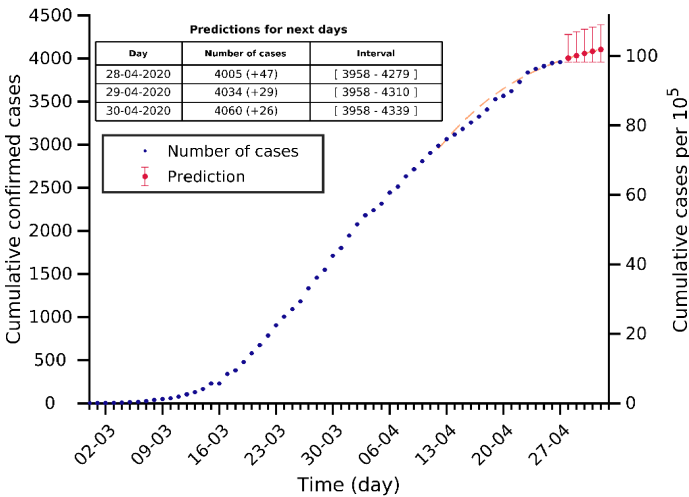




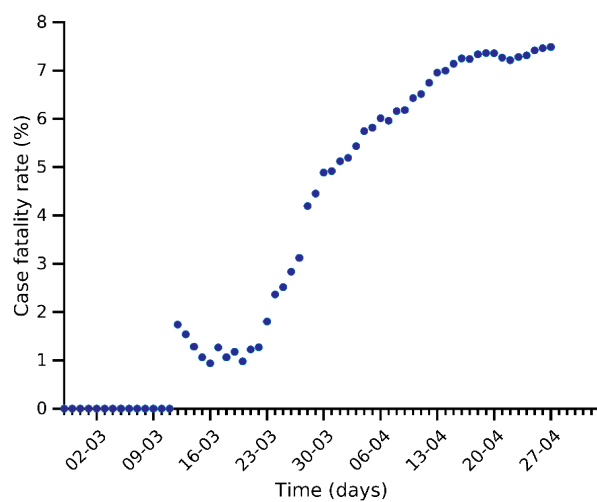
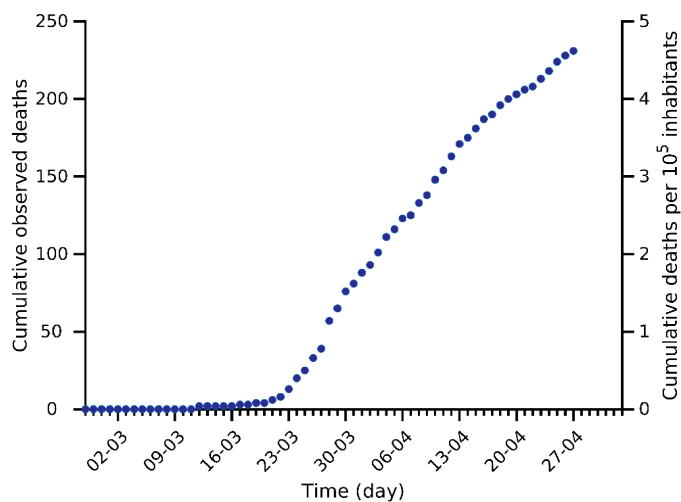
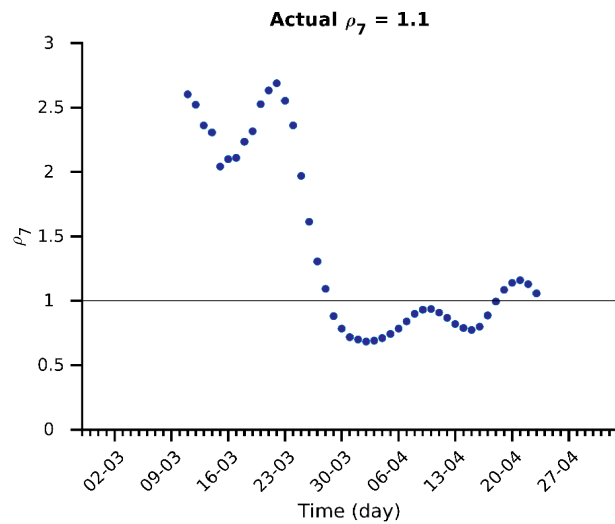
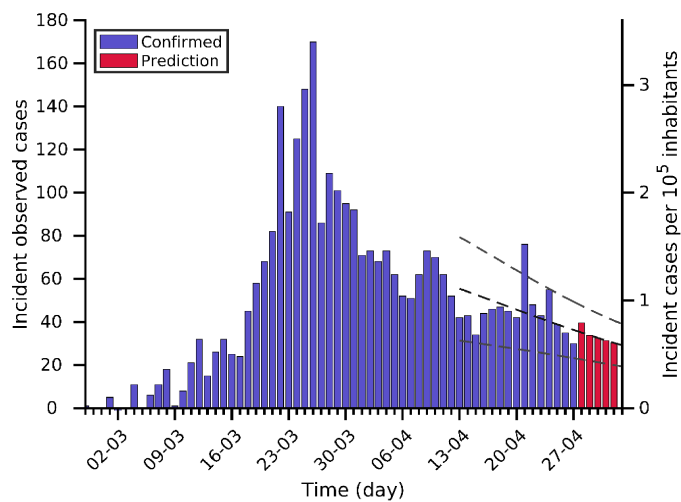
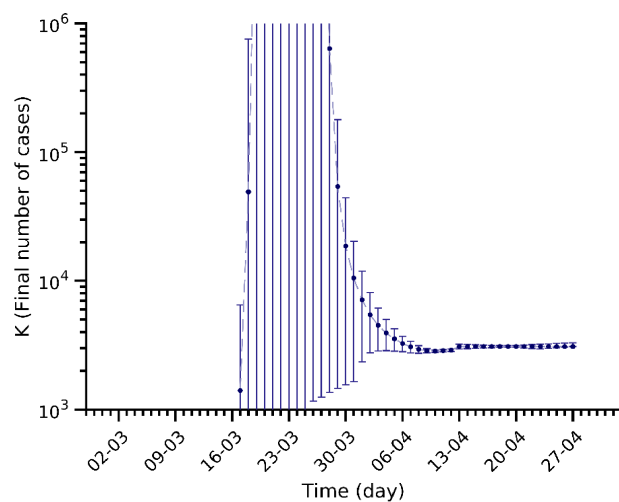
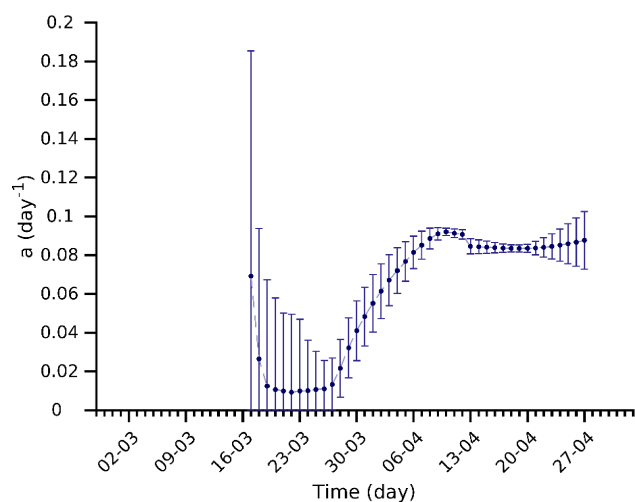
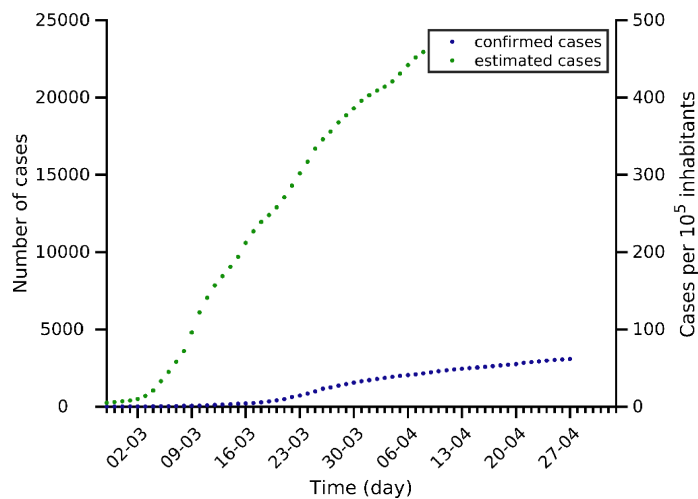
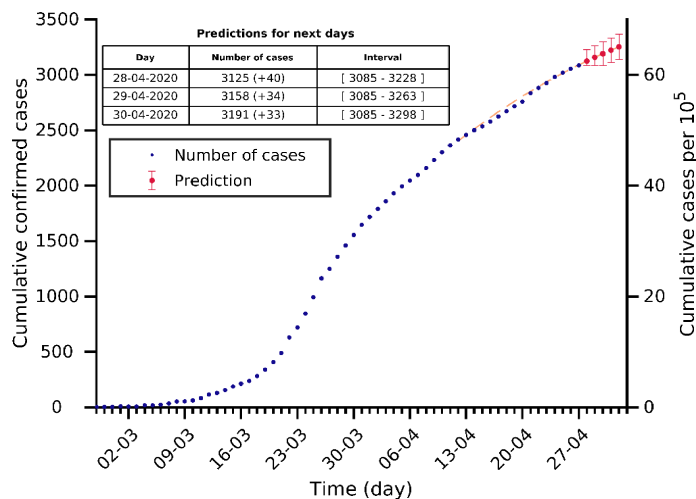
# Trento 27-04-2020. Population: 0.5M. Current cumulated incidence: 743/10<sup>5</sup>



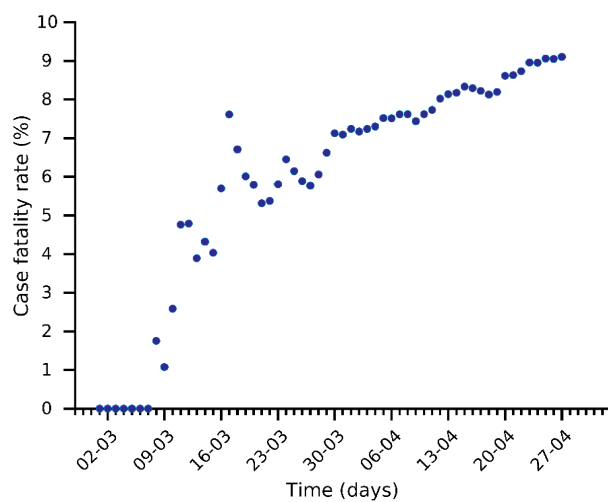
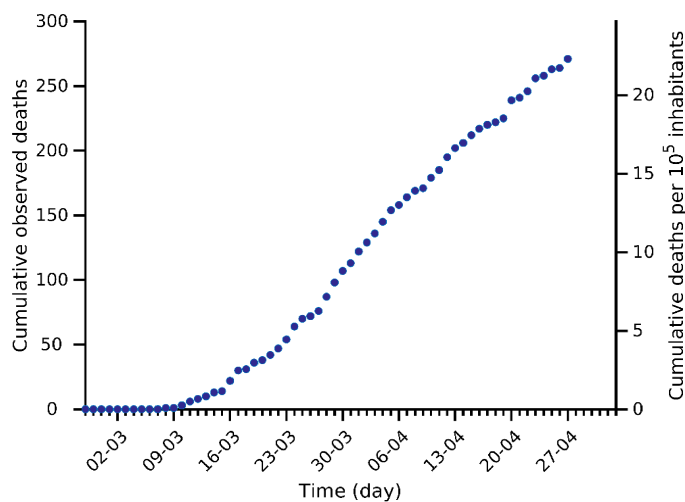
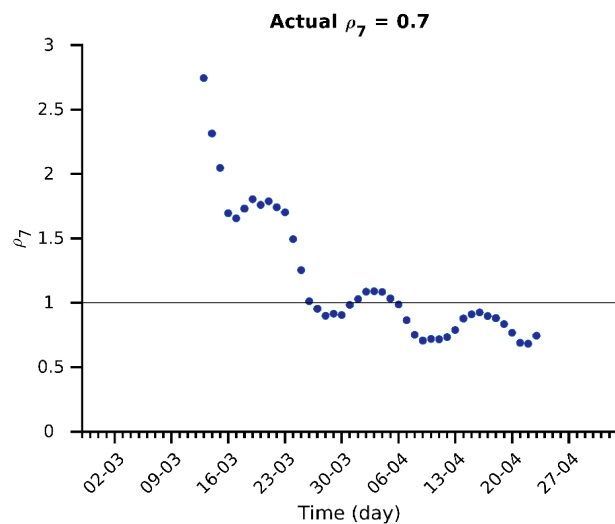
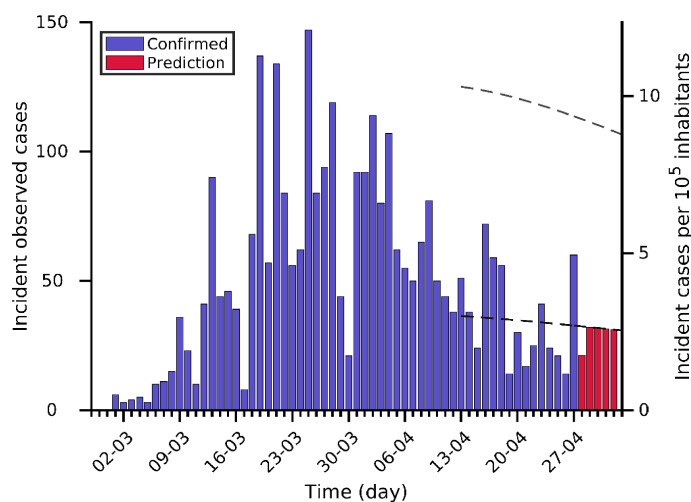
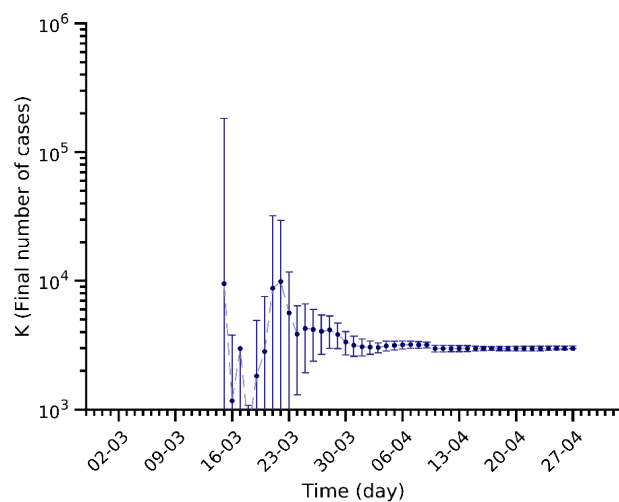
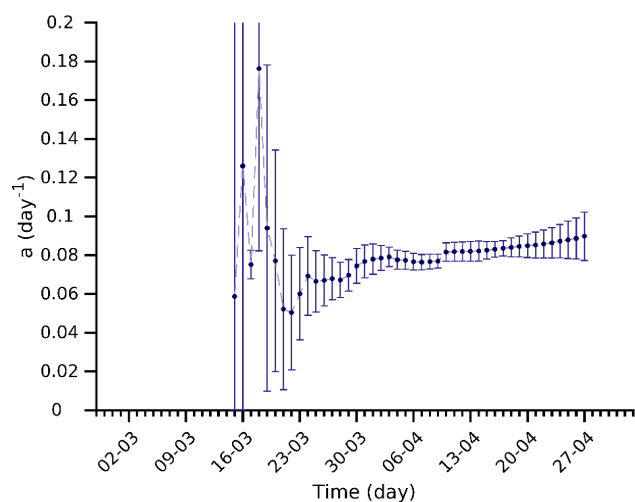
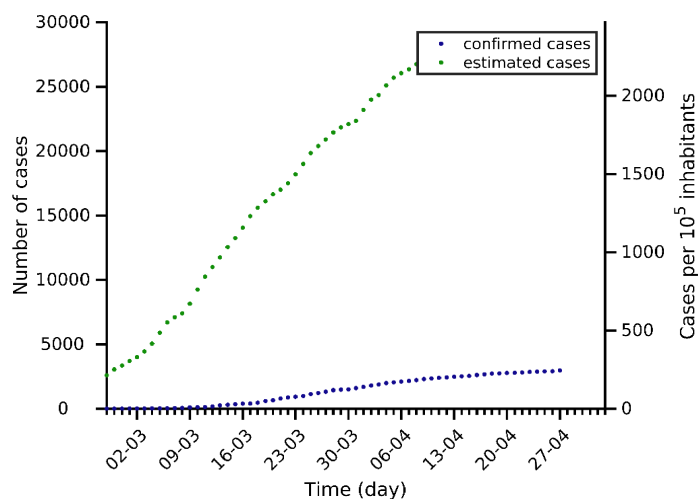
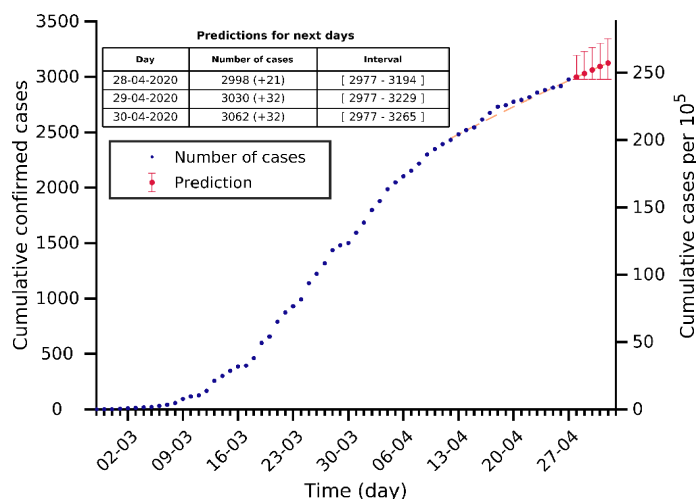
Puglia 27-04-2020. Population: 4.0M. Current cumulated incidence: 98/10<sup>5</sup>



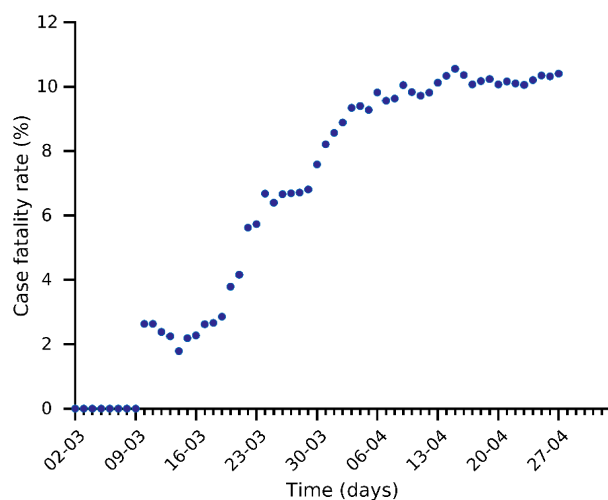
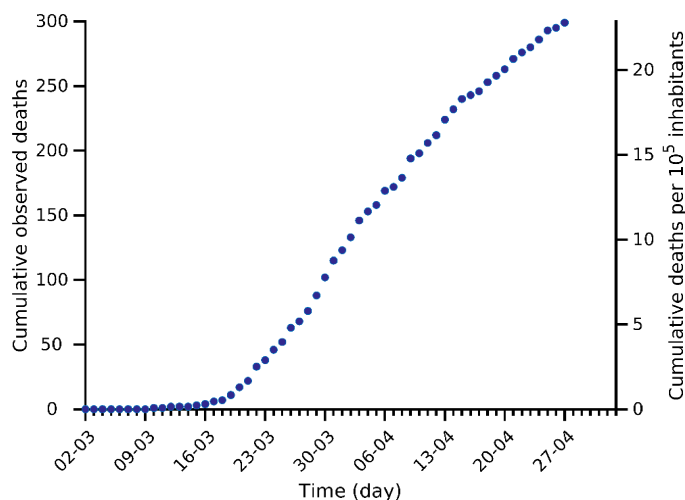
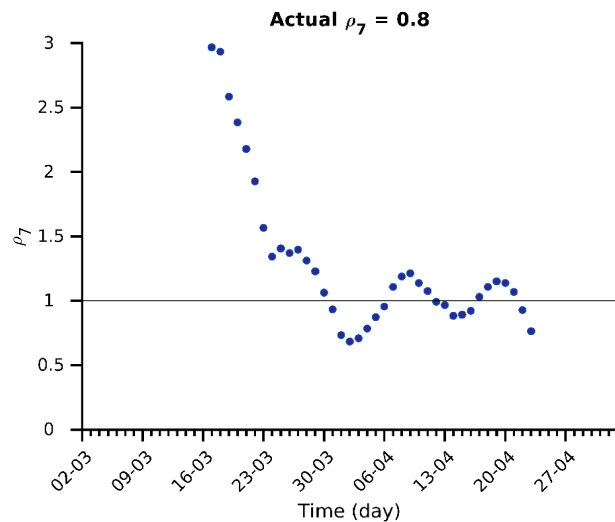
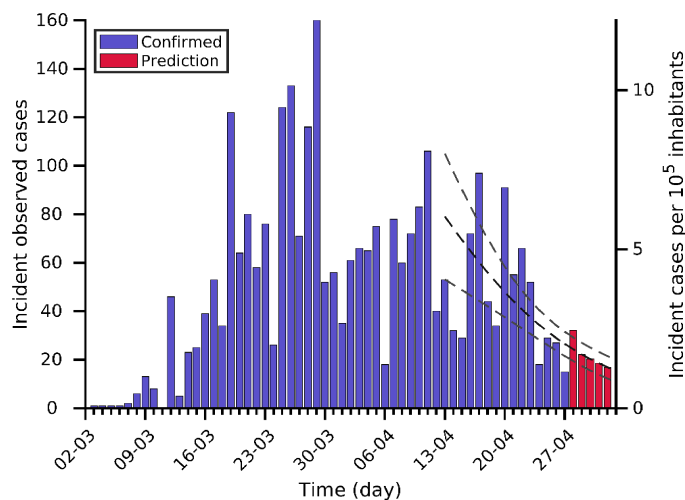
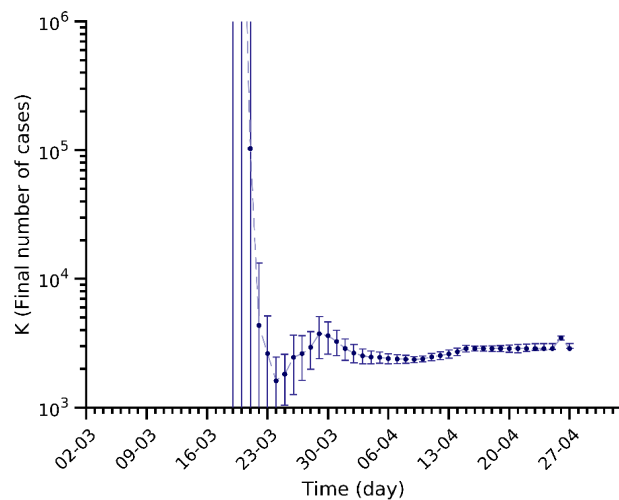
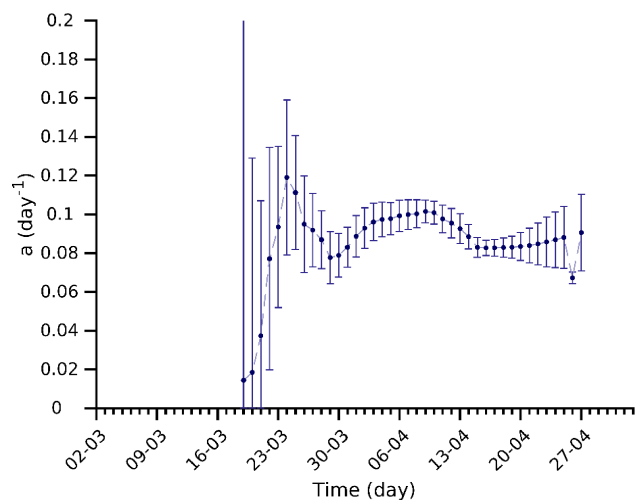
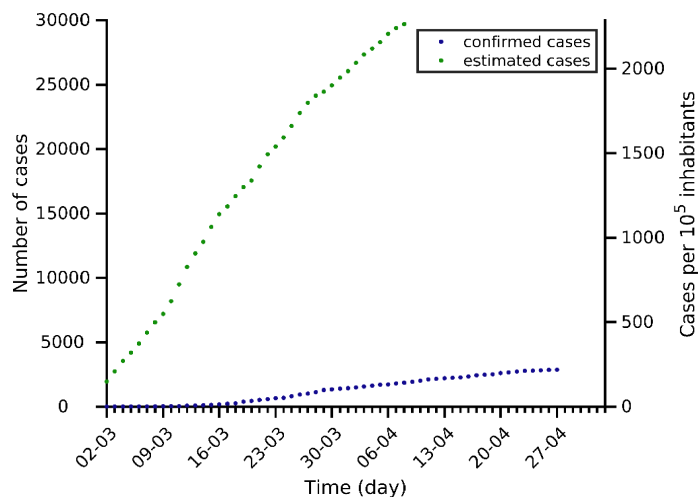
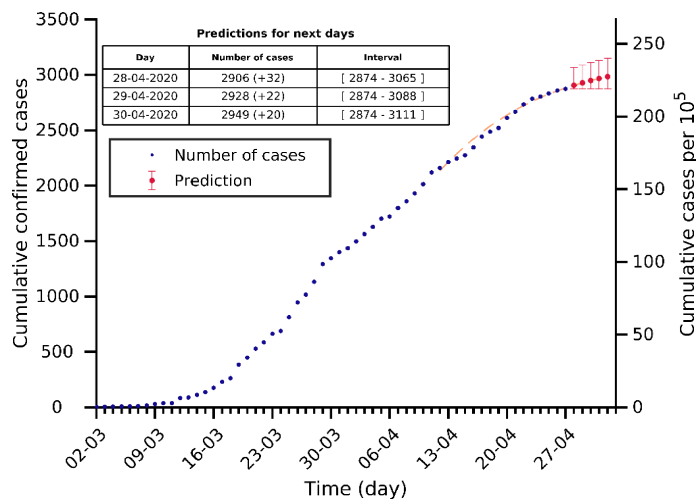
# Sicilia 27-04-2020. Population: 5.0M. Current cumulated incidence: 62/10<sup>5</sup>



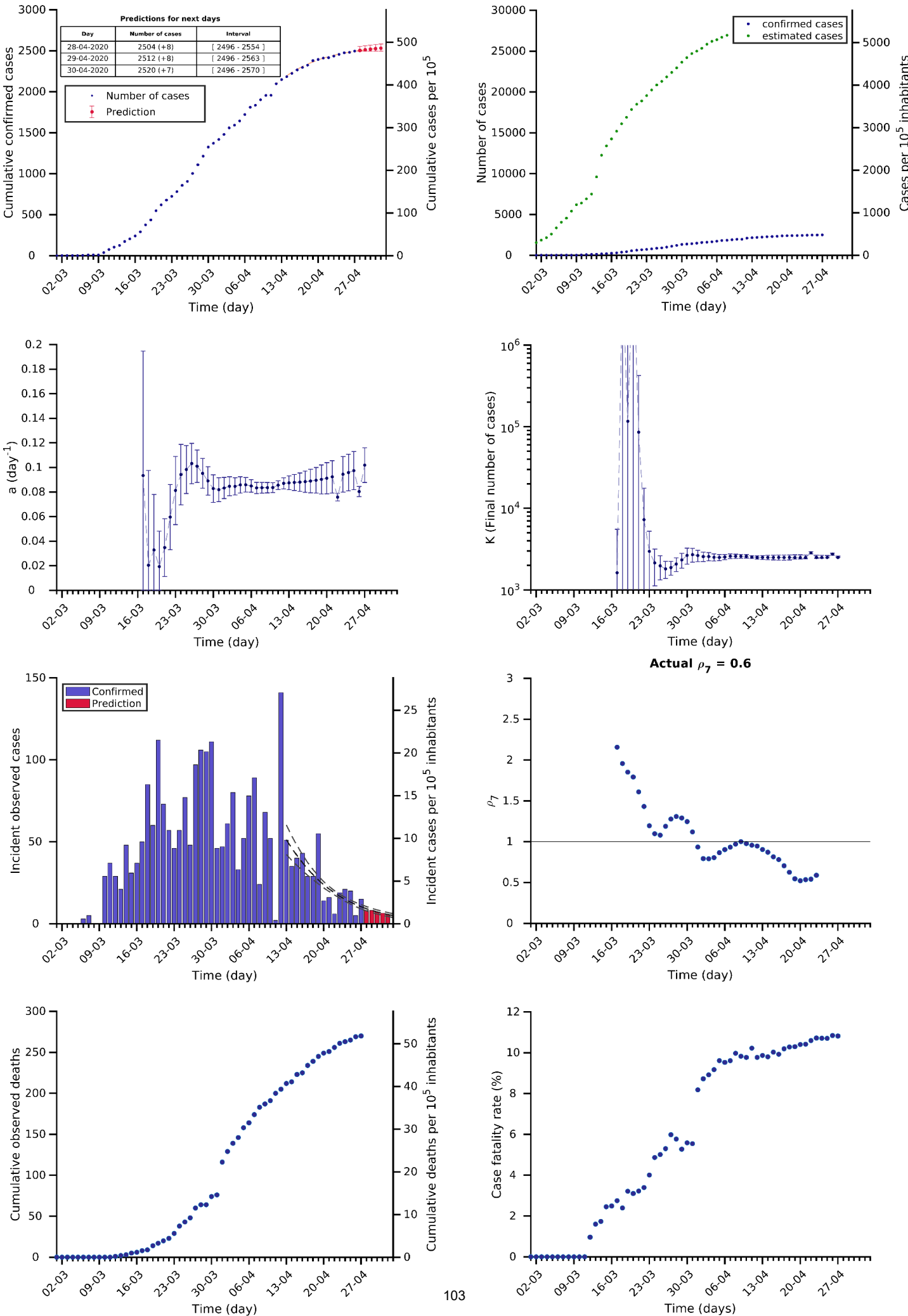
# Friuli Venezia Giulia 27-04-2020. Population: 1.2M. Current cumulated incidence: 2



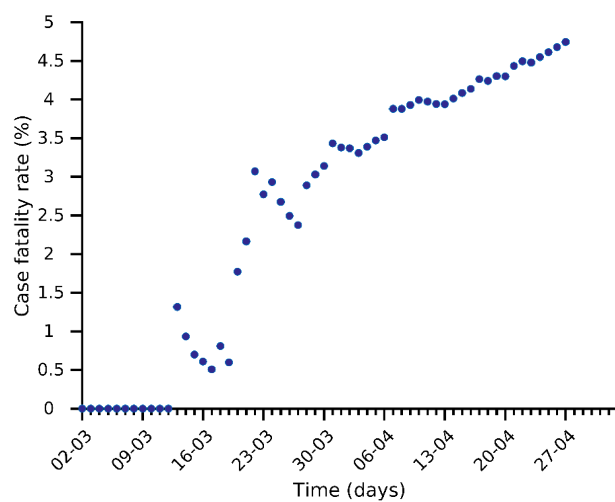
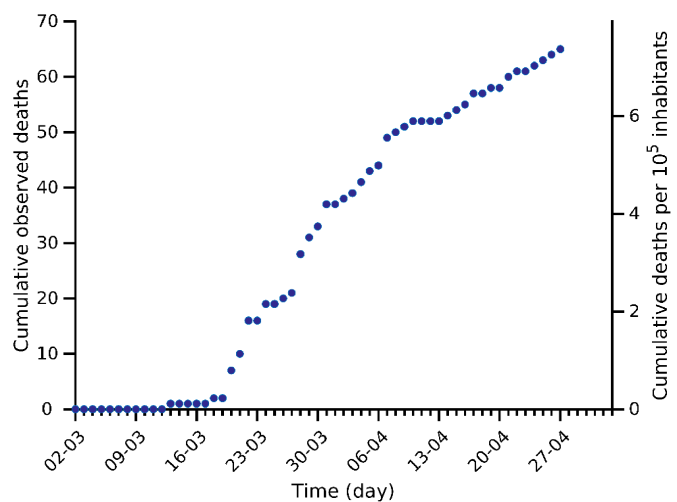
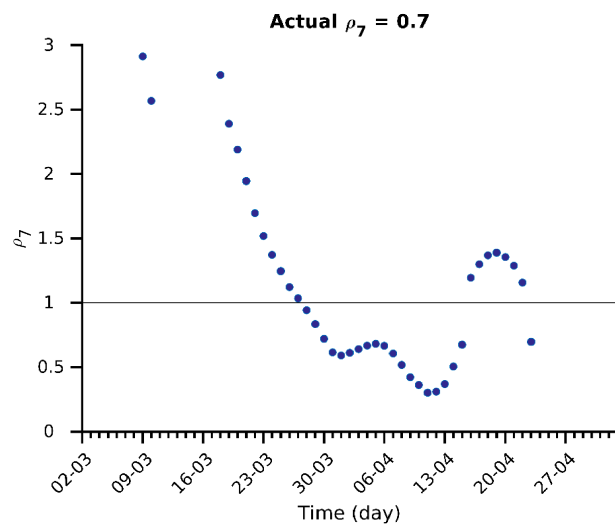
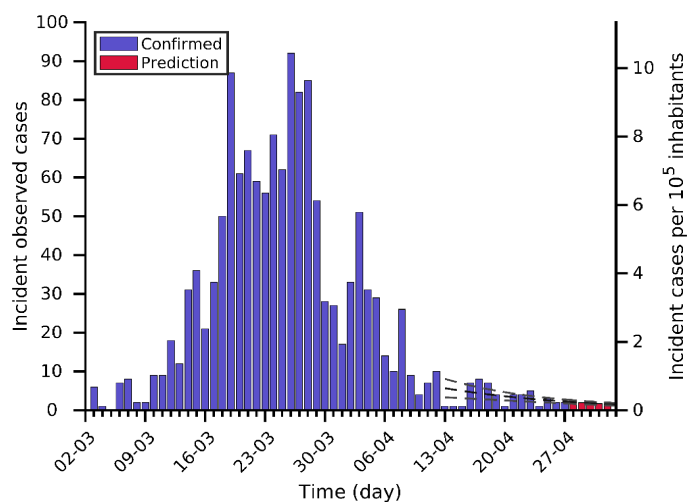
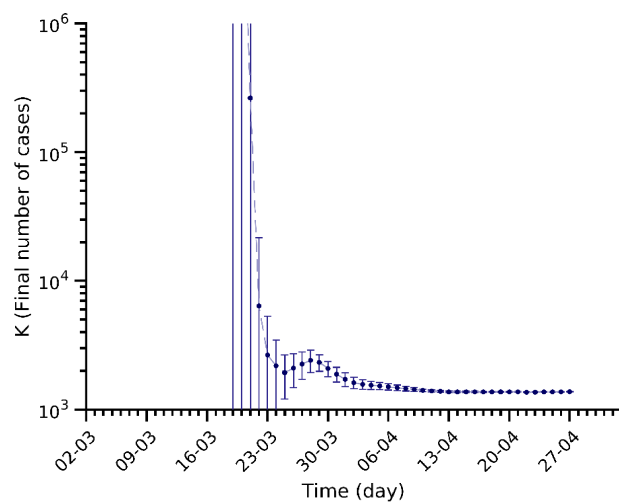
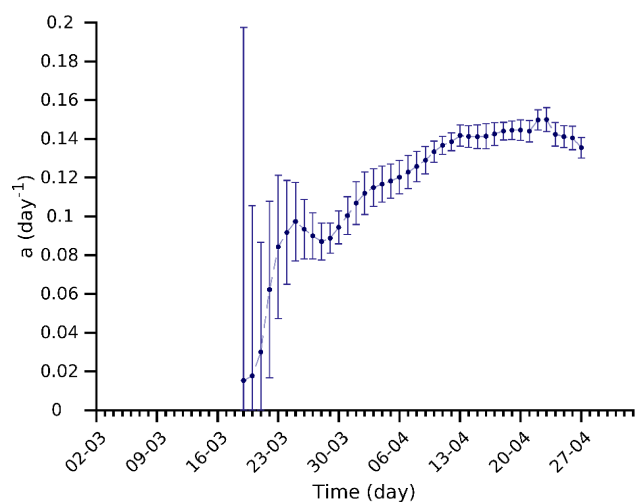
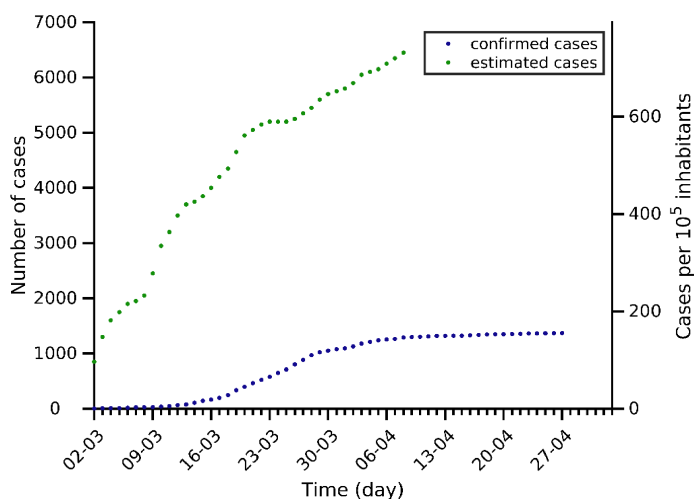
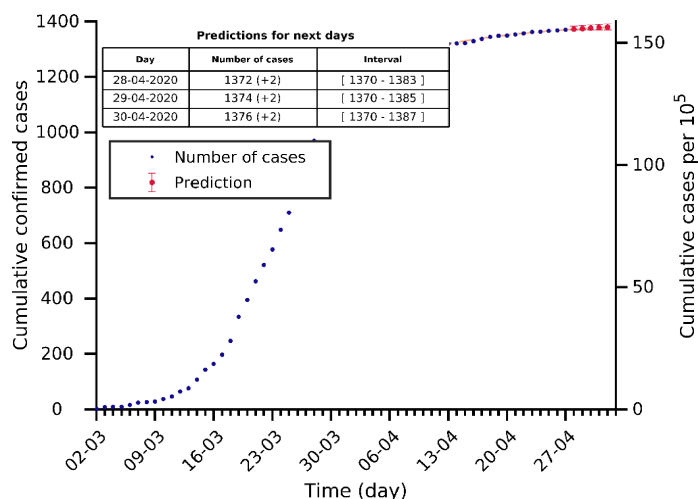
# Abruzzo 27-04-2020. Population: 1.3M. Current cumulated incidence: 219/10<sup>5</sup>



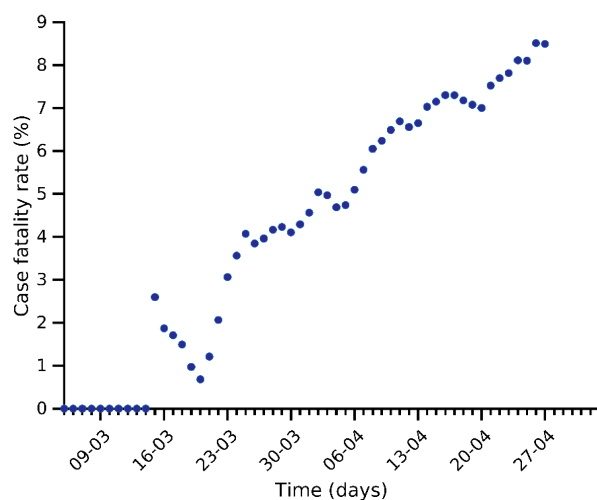
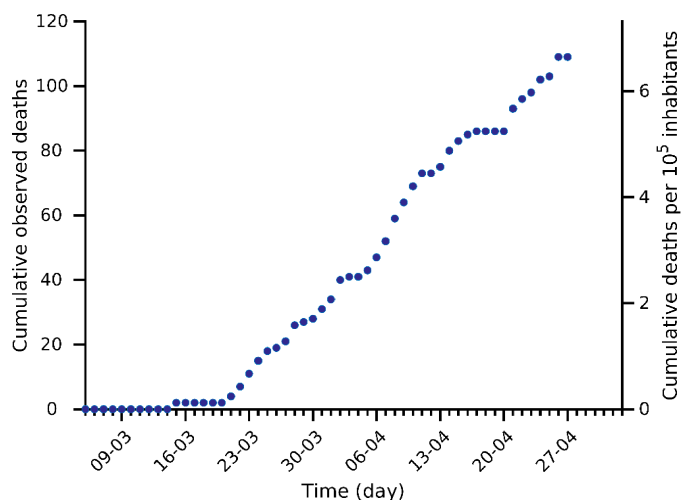
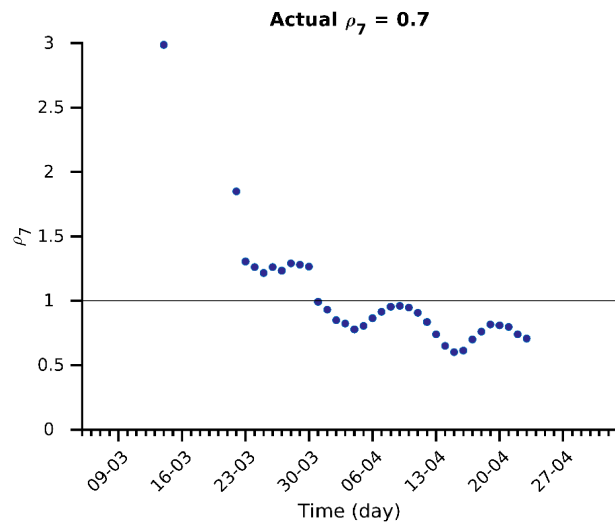
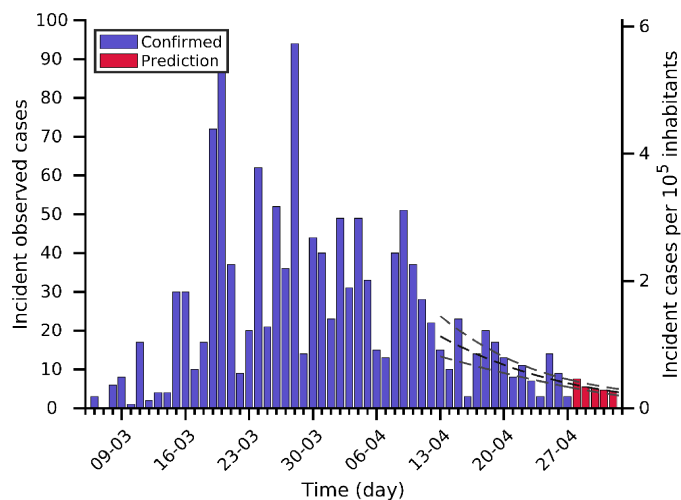
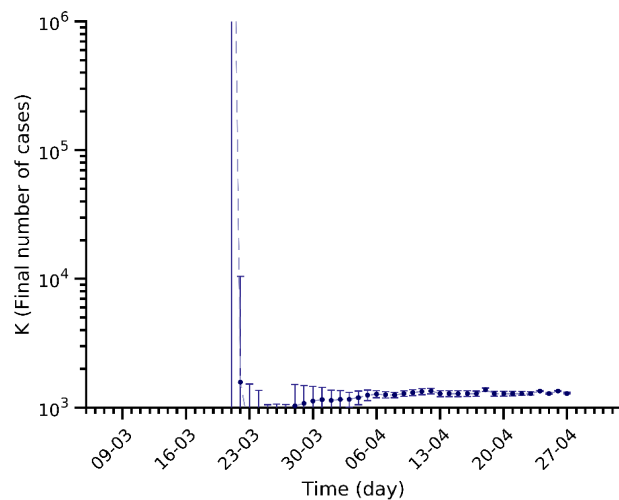
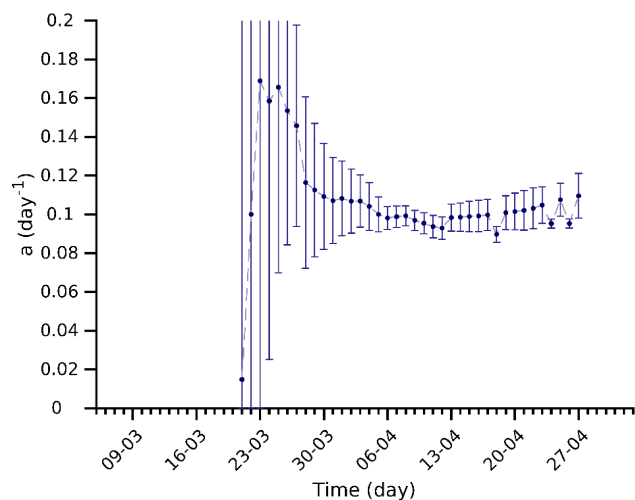
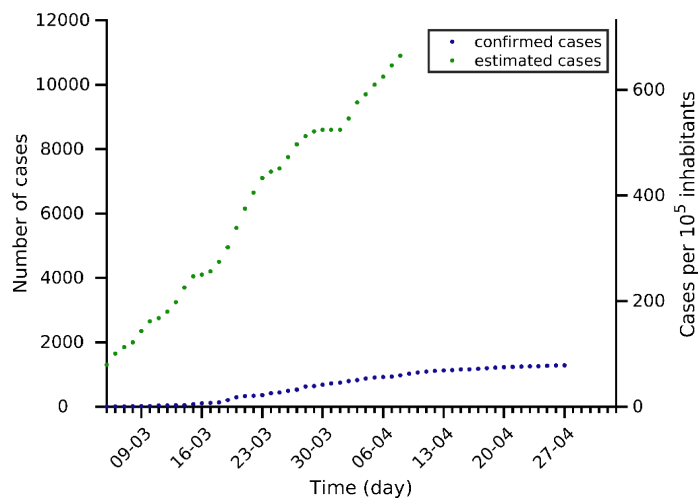
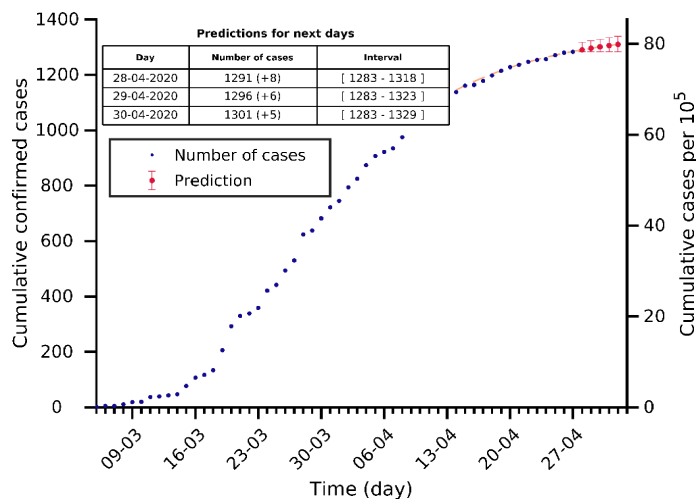
**Bolzano 27-04-2020. Population: 0.5M. Current cumulated incidence: 479/10<sup>5</sup>**



# Umbria 27-04-2020. Population: 0.9M. Current cumulated incidence: 155/10<sup>5</sup>

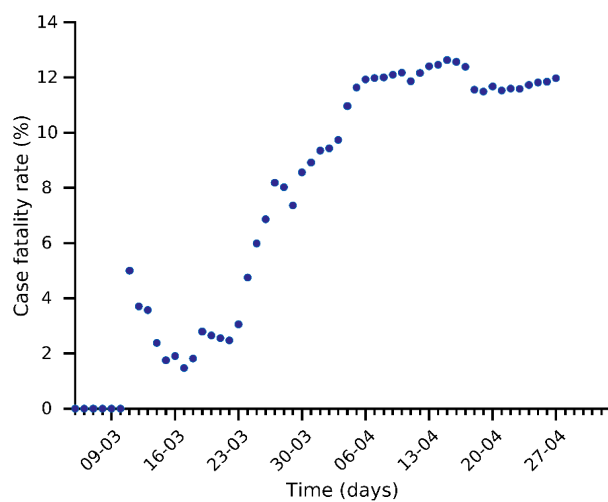
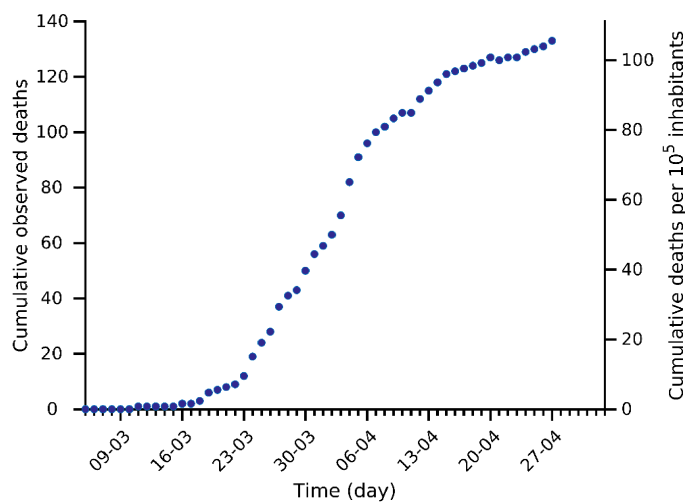
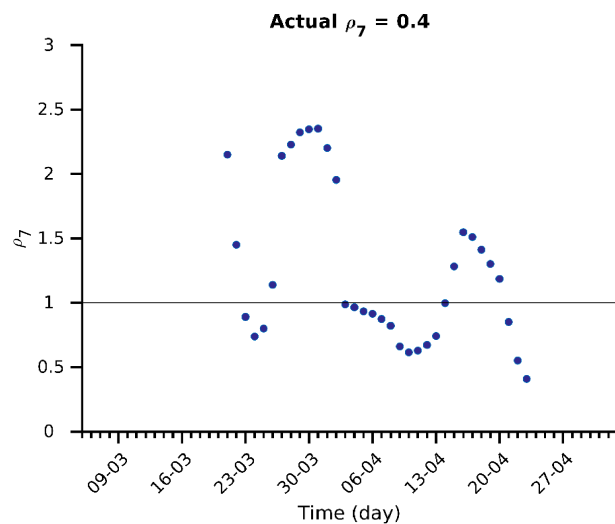
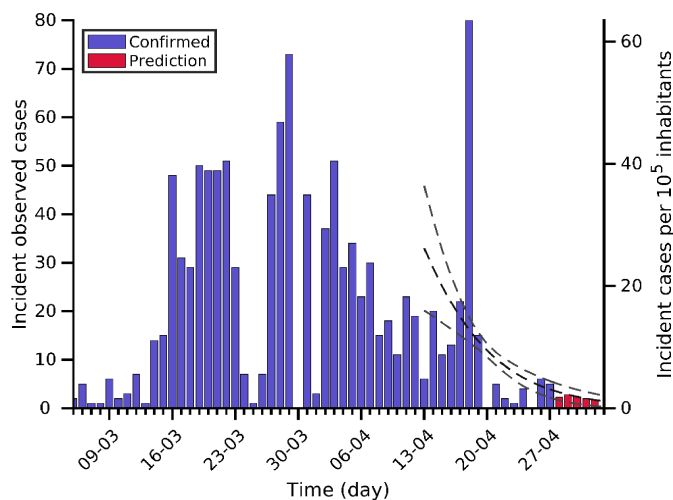
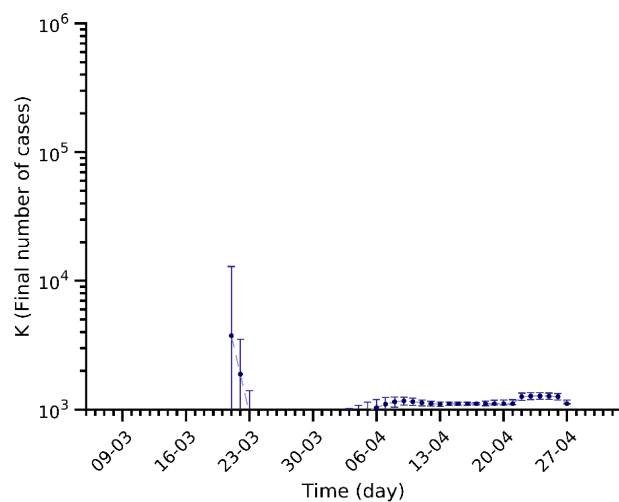
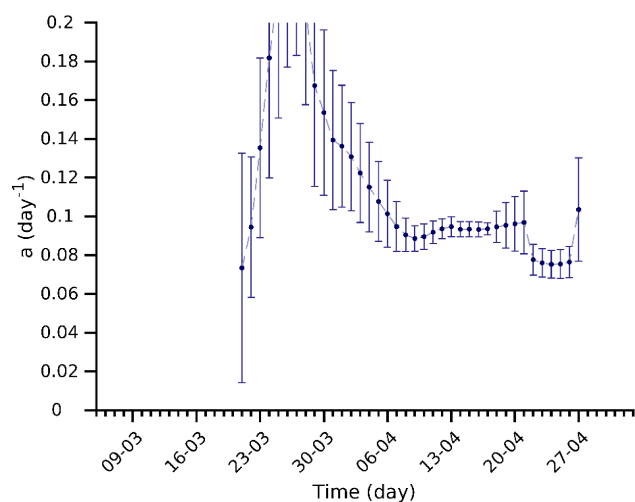
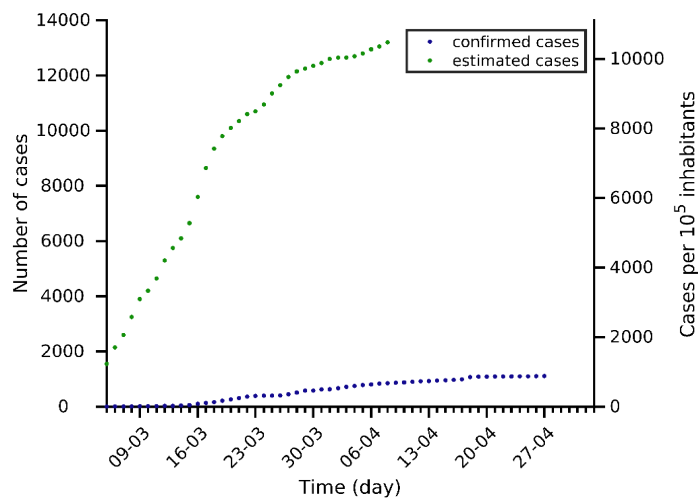
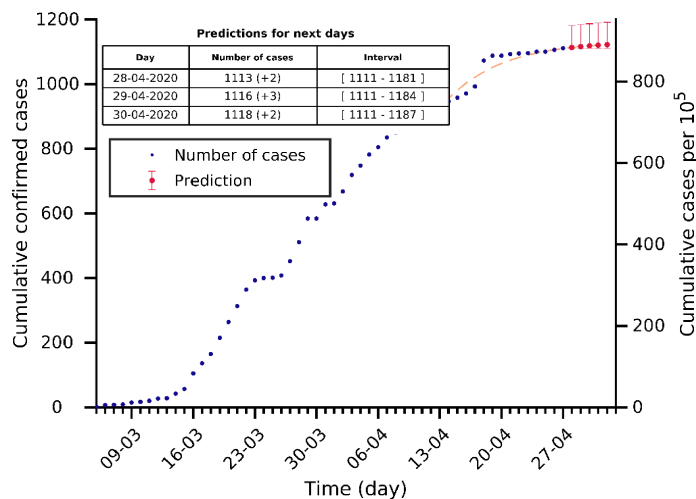


# Sardegna 27-04-2020. Population: 1.6M. Current cumulated incidence: 78/10<sup>5</sup>

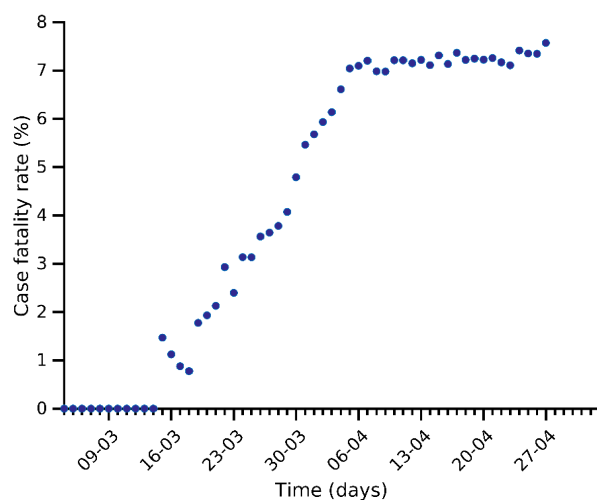
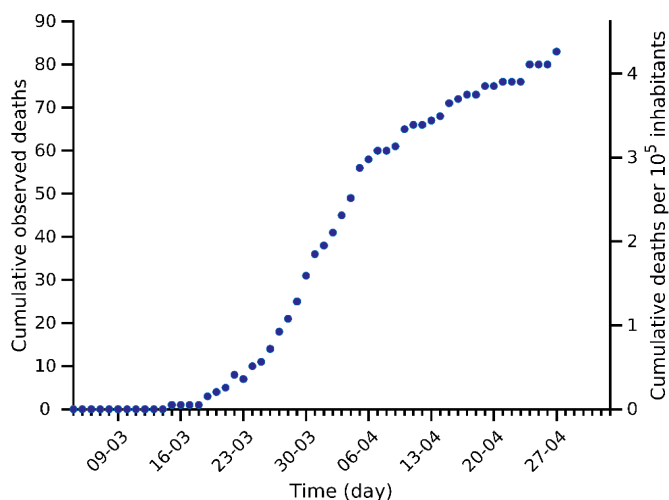
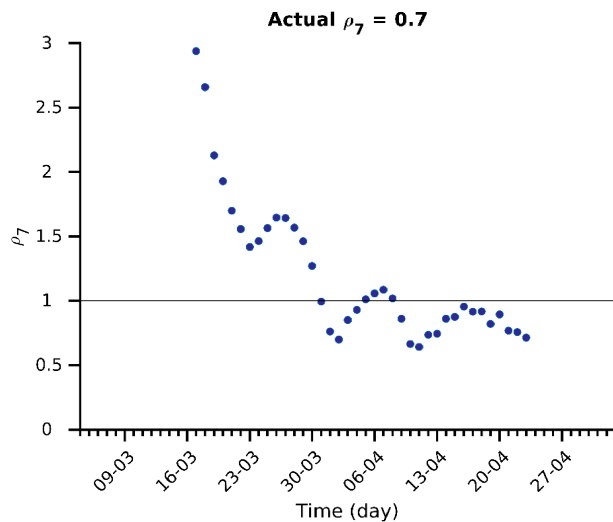
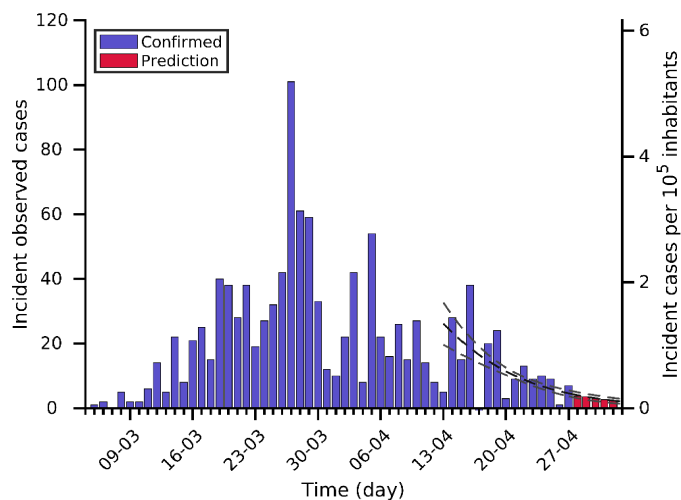
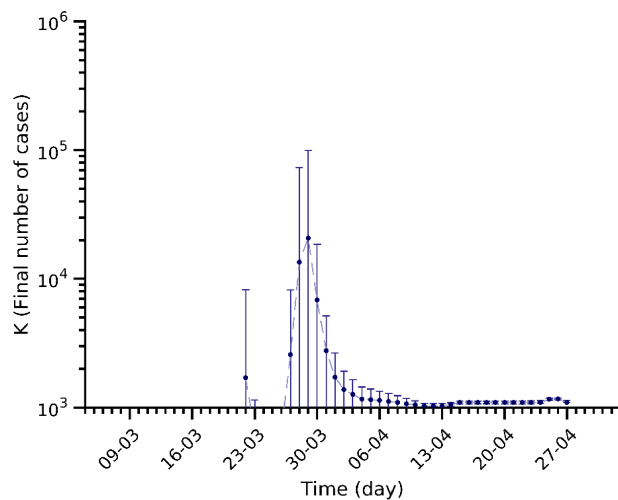
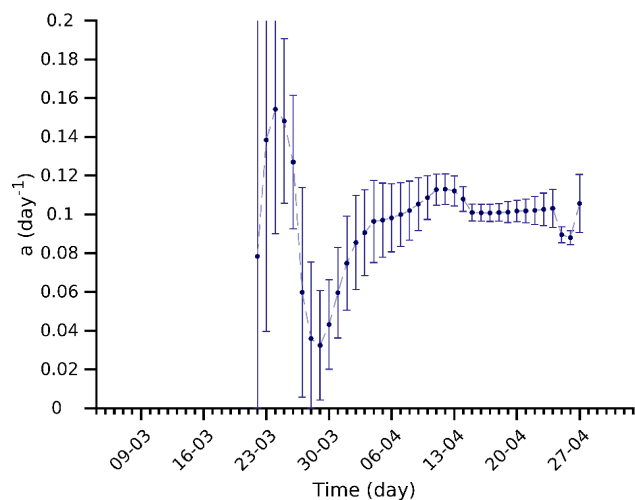
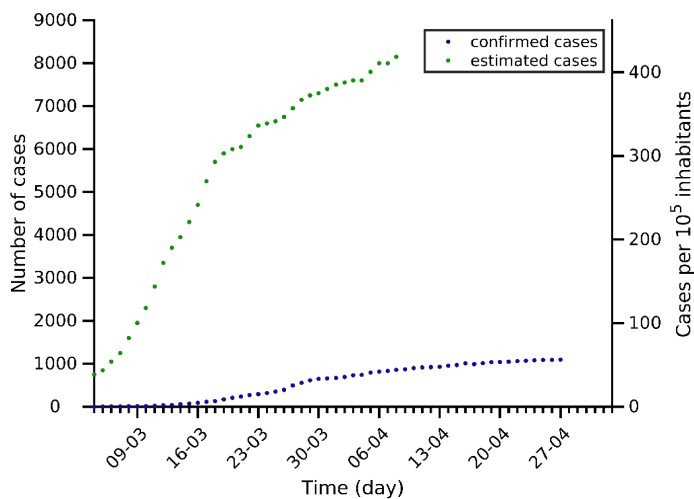
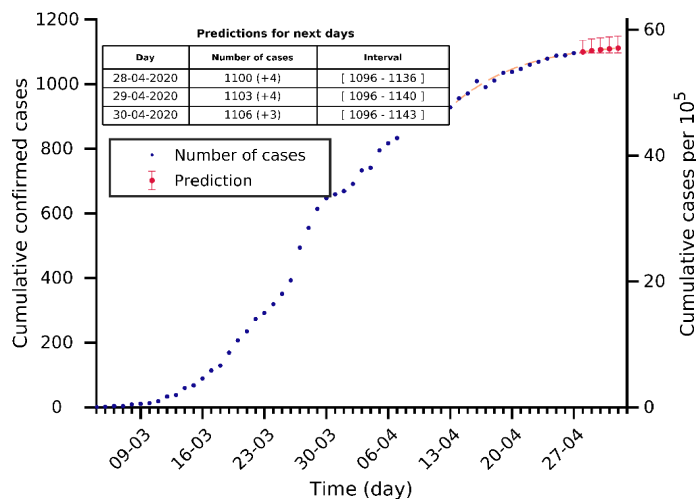




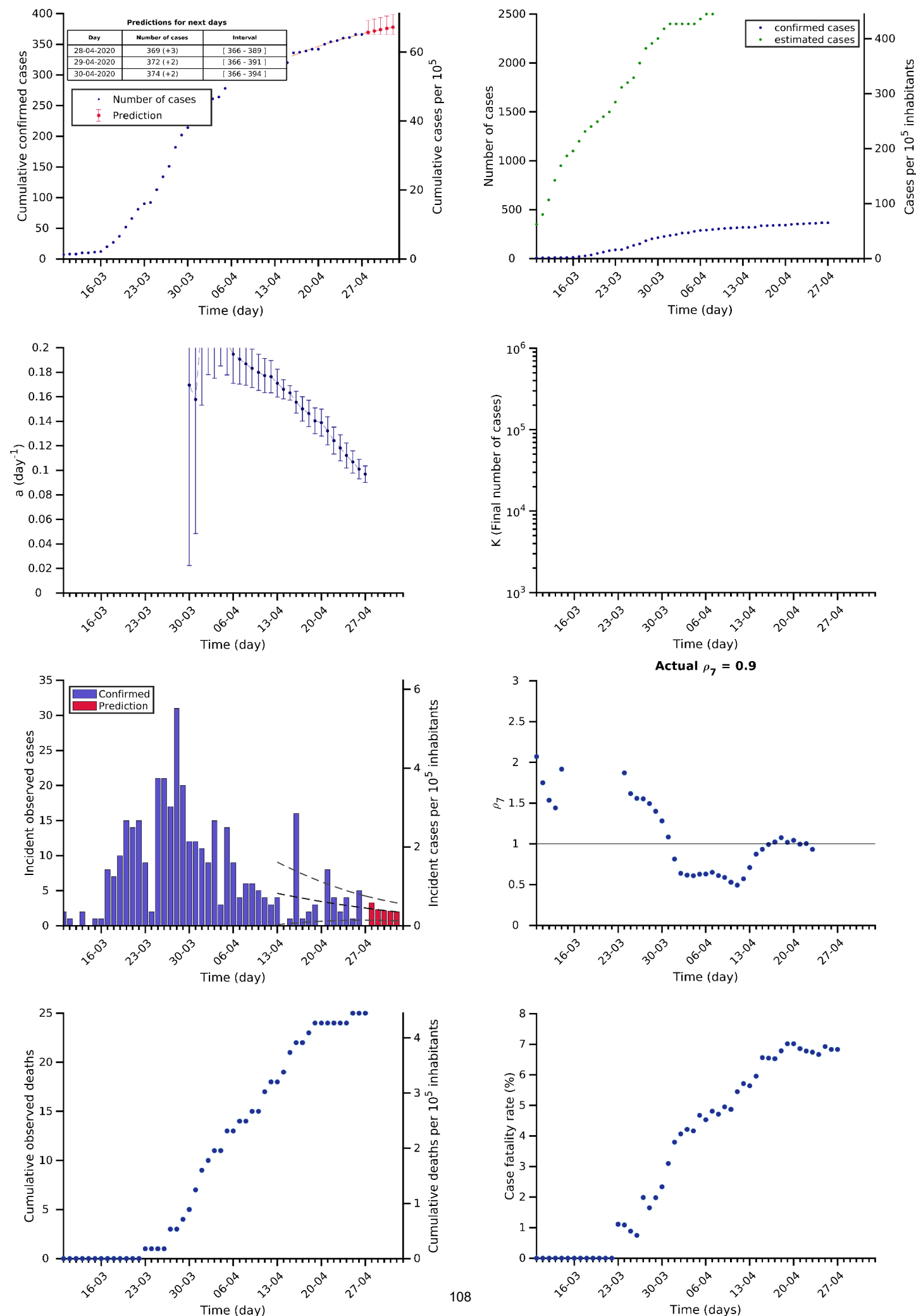
# Valle d'Aosta 27-04-2020. Population: 0.1M. Current cumulated incidence: 882/10<sup>5</sup>



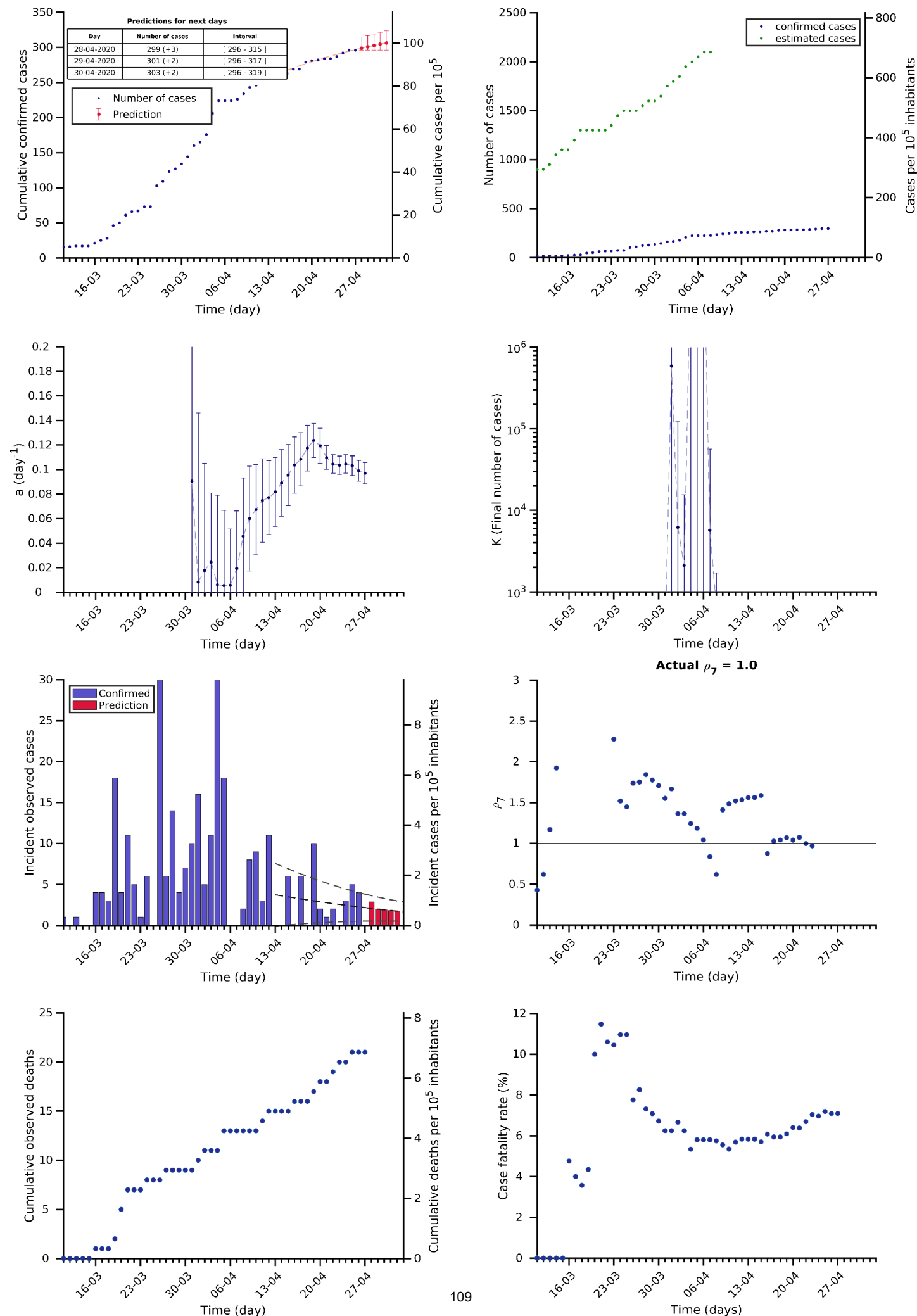
# Calabria 27-04-2020. Population: 1.9M. Current cumulated incidence: 56/10<sup>5</sup>



# Basilicata 27-04-2020. Population: 0.6M. Current cumulated incidence: 65/10<sup>5</sup>



# Molise 27-04-2020. Population: 0.3M. Current cumulated incidence: 97/10<sup>5</sup>



## Methods

## Methods

### **(1) Data source**

Data are daily obtained from World Health Organization (WHO) surveillance reports<sup>1</sup>, from European Centre for Disease Prevention and Control (ECDC)<sup>2</sup> and from Ministerio de Sanidad<sup>3</sup>. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

### **(2) Data processing and plotting**

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓  $\rho$ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ( $t-1$ ):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where  $N_{new}(t)$  is the number of new confirmed cases at day  $t$ .

### **(3) Classification of countries according to their status in the epidemic cycle**

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

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<sup>1</sup> <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

<sup>2</sup> <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

<sup>3</sup> <https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>  
<https://github.com/datadista/datasets/tree/master/COVID%2019> , <https://covid19.isciii.es/>

#### **(4) Fitting a mathematical model to data**

Previous studies have shown that Gompertz model<sup>4</sup> correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where  $N(t)$  is the cumulated number of confirmed cases at  $t$  (in days), and  $N_0$  is the number of cumulated cases the day at day  $t_0$ . The model has two parameters:

- ✓  $a$  is the velocity at which specific spreading rate is slowing down;
- ✓  $K$  is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day  $t_0$  is chosen as that one at which  $N(t)$  overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters ( $a$  and  $K$ ) and the  $R^2$  of the fitting. At the initial stages the dynamics is exponential and  $K$  cannot be correctly evaluated. In fact, at this stage the most relevant parameter is  $a$ . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted  $a$  with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted  $K$  with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if  $a > 0.2 \text{ day}^{-1}$ , if  $K > 10^6$  or if the error in  $K$  overpasses  $10^6$ .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

#### **(5) Using the model for predicting short-term tendencies**

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

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<sup>4</sup> Madden LV. Quantification of disease progression. Protection Ecology 1980; 2: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days<sup>5</sup>;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

### ***(6) Estimating non-diagnosed cases***

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors<sup>6</sup> in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

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<sup>5</sup> At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

<sup>6</sup> Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3